2021-06

PREPARING FOR THE NEXT PANDEMIC: HOW CAN NAVY PERSONAL PROTECTIVE EQUIPMENT RESUPPLY BE IMPROVED?

Encoy, Michael C.

Monterey, CA; Naval Postgraduate School

http://hdl.handle.net/10945/67707

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

PREPARING FOR THE NEXT PANDEMIC: HOW CAN NAVY PERSONAL PROTECTIVE EQUIPMENT RESUPPLY BE IMPROVED?

by

Michael C. Encoy

June 2021

Thesis Advisor:	Douglas J. MacKinnon
Second Reader:	Steven J. Iatrou

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REPORT DOCUMENTATION PAGE				*Form Approved OMB No. 0704-0188*
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington, DC 20503.				
1. AGENCY USE ONLY ***(Leave blank)***	**2. REPORT DATE** June 2021	**3. REPORT TYPE AND DATES COVERED** Master's thesis		
4. TITLE AND SUBTITLE PREPARING FOR THE NEXT PANDEMIC: HOW CAN NAVY PERSONAL PROTECTIVE EQUIPMENT RESUPPLY BE IMPROVED?				**5. FUNDING NUMBERS**
6. AUTHOR(S) Michael C. Encoy				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000				**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A				**10. SPONSORING / MONITORING AGENCY REPORT NUMBER**
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release. Distribution is unlimited.				**12b. DISTRIBUTION CODE** A

13. ABSTRACT (maximum 200 words)

As a result of the COVID-19 pandemic, Commander, Naval Surface Forces U.S. Pacific Fleet (CNSP) is reevaluating shipboard allowances of medical supplies/Personal Protective Equipment (PPE). We sought to positively impact the response at the ship and fleet levels through an evaluation of notional modifications to supply chain practices, thus increasing resiliency for the next pandemic. An exploratory sequential mixed-method research design was used to address two research questions. (1) How can the Navy provide frontline subject matter experts the means to efficiently and accurately track PPEs during COVID-19 type pandemics? (2) How can the Navy determine a reasonable onboard allowance for pandemic-related PPE (given limits on shipboard storage and Authorized Medical Allowance List [AMAL] composition), and an empirically-sound prediction for the usage rate of each category of PPE during a pandemic? The findings identified potential areas of improvement in training, operational supply chain practices, and on-hand N95 mask DDG inventory. To establish viable PPE supply chain management practices, we illustrate how enhanced data standards might be implemented using an optimized Re-order Point (ROP) model, as well as a sustainment of AMAL review boards. We also offer that supply chain training for corpsmen might offer potential improvement to overall shipboard inventory.

14. SUBJECT TERMS COVID-19, pandemic, Commander, Naval Surface Forces U.S. Pacific Fleet, CNSP, supply chain, optimization, pre-positioning, Personal Protective Equipment, PPE, medical, Authorized Medical Allowance List, AMAL, Re-order Point, ROP			**15. NUMBER OF PAGES** 83
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UU

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

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Michael C. Encoy
Lieutenant, United States Navy
BA, University of Maryland University College, 2007
MS, California State University, Long Beach, 2013

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN NETWORK OPERATIONS AND TECHNOLOGY

from the

NAVAL POSTGRADUATE SCHOOL
June 2021

Approved by: Douglas J. MacKinnon
Advisor

Steven J. Iatrou
Second Reader

Alex Bordetsky
Chair, Department of Information Sciences

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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LIST OF ACRONYMS AND ABBREVIATIONS

AFMOA	Air Force Medical Operations Agency
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AMAL	Authorized Medical Allowance List
CDC	Centers for Disease Control and Prevention
CNSP	Commander, Naval Surface Forces U.S. Pacific Fleet
COVID-19	“CO” stands for corona, ‘ “VI”‘ for virus, and ‘ “D”‘ for disease
CVN	Aircraft Carrier (nuclear propulsion)
DDG	Destroyer, Guided Missile
DESRON	Destroyer Squadron
DHA	Defense Health Agency
DHA MEDLOG	Defense Health Agency Medical Logistics
DMLE	Defense Medical Logistics Enterprise
DOD	Department of Defense
FCO	Fleet Concentration Areas
HM	Hospital Corpsman
IDC	Independent Duty Corpsman
LHD	Landing Helicopter Dock
LPD	Landing Platform Docks
LSD	Dock Landing Ship
MARCOSYSCOM	Marine Cops System Command
NAVMEDLOGCOM	Navy Medical Logistics Command
NAVSUP	Naval Supply Systems Command
NIOSH	National Institute for Occupational Safety & Health
OPNAV	Office of the Chief of Naval Operations
ORP	Optimal Re-order Point
OSHA	Occupational Safety and Health Administration
PACFLT	United States Pacific Fleet
PPE	Personal Protective Equipment
ROM	Restriction of Movement

ROP	Reorder Point
SAILOR	SPAWAR Acquisition Integrated Logistics Repository
SAMS	Shipboard Automated Medical Systems
SPAWAR	Space and Naval Warfare Systems Command
SPY-1D	3D Radar System
SURFOR	Surface Force
TMIP	Theatre Medical Information Program
USAMMA	US Army Medical Material Agency
USAMRMC	US Army Medical Research and Material Command
WHO	World Health Organization

ACKNOWLEDGMENTS

To my professors, fellow students, and the staff of Naval Postgraduate School, thank you for your tutelage, guidance, and support throughout these rewarding two years. I have learned immensely from each of you; you have all made my graduate studies here a pleasure and a fulfilling experience. My sincere gratitude must also go to my advisor, Dr. Douglas MacKinnon. Thank you for your direction and patience as you led me through the research evolution of this study. For the Independent Duty Corpsmen who took part in this study, thank you for your contribution. You all continue to represent Navy Medicine as great leaders of the Hospital Corps.

Lastly, to my parents, Evelyn and Enrique, thank you for raising me to think freely and find my own way in life. I cannot thank you enough for life and the paths I have been fortunate enough to take. To my wife, Crystal, thank you for continuing to be the rock while sacrificing so much for our precious children and me. And to my children, Chloe, Cruz, and Cole. Thank you for always being my inspiration; you all make me beyond proud to be your father.

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I. INTRODUCTION

In the wake of the 2020 COVID-19 pandemic, Commander, Naval Surface Forces U.S. Pacific Fleet (CNSP) is reevaluating current shipboard allowances of medical supplies such as Personal Protective Equipment, PPE (masks, gloves, etc.), and disinfecting supplies (hand sanitizers, disinfecting solutions). To plan for the next pandemic, CNSP is seeking supply chain solutions to increase resiliency in the face of potential challenges that stem from shipboard outbreaks.

Private sector practices have prevailed as standards of medical supply chain solutions, but during COVID-19 they were not impervious to extreme cases of PPE scarcity. Rising cases in the United States caused shortages to N-95 high filtration masks, prompting proposed contingency practices that called for the reuse of these single-use PPEs (CDC, 2020a). With such medical supply chain instability, healthcare workers lose the will to fully partake in response efforts or have increased risk of infections (WHO, 2014). Challenges similar to these have the potential of affecting the Navy's operations with minimal mitigation options to adopt due to the pandemic's novel effects to national medical supply inventories. In the case of the Navy's healthcare workers in the shipboard environment, supply chain challenges are further amplified by their remote locations while underway where sourcing supply outside of standard allotted inventories becomes problematic with logistical variations.

A. PROBLEM STATEMENT

Since the WHO first declared the pandemic as a global health emergency on January 30, 2020 (WHO, 2020b) COVID-19 cases have continued to increase; healthcare organizations have struggled to meet the demand of equipping their essential workers with the necessary PPEs (Ranney et al., 2020) to minimize infection risk. The Navy fully appreciates the potential risk of PPE shortages, not only at individual incident level, but also to the more significant potential cumulative effects to the fleet and its overall combat readiness. To mitigate the adverse effects of potential PPE shortage, the Navy, through the sponsorship of this study by the Force Surgeon (CNSP), has pivoted toward proactive measures in addressing supply chain inefficiencies in the next pandemic. Specifically, the problem is the overarching potential of PPE shortages to the fleet, the adverse effects to overall readiness, and the preservation of the Navy's greatest assets, its sailors.

B. PURPOSE STATEMENT AND OBJECTIVE

The purpose of this study is to positively impact COVID-19 response at the ship and fleet levels through an evaluation of notional modifications to supply chain practices, thereby increasing resiliency for the next pandemic. Our findings seek to recommend minimum requirements for on-hand shipboard inventory (PPE) to sustain fleet assets through an extended pandemic similar to COVID-19. These revised inventory plans can then inform updated inventory and re-supply policy that can maintain readiness, support U.S. Navy missions, maintain projection of power, and save lives.

C. RESEARCH QUESTIONS

The author of this study will attempt to pose and address questions focused on Fleet Concentration Areas (FCA) and examining medical logistics policies that support and drive operational practices. Evaluation of optimized notional pandemic supply inventories will also be a focus to ensure assured access and rapid replenishment to fleet assets (DDGs). These research questions are:

1. How can the Navy provide frontline Subject Matter Experts (Independent Duty Corpsman—IDC) the means to efficiently and accurately track PPEs during COVID-19 type pandemics?
2. How can the Navy determine a reasonable onboard allowance for pandemic-related PPE given limits on shipboard storage and Authorized Medical Allowance List (AMAL) composition and an empirically-sound prediction for the usage rate of each category of PPE during a pandemic?

D. HYPOTHESIS

This thesis aims to improve PPE tracking and reordering practices at the ship level to increase operational resiliency in the next pandemic. This increased resiliency is important to the IDCs as they are able to concentrate efforts in the direct care of sailors while minimizing the risks of depletion of onboard PPE stocks. This study's effort will also benefit the Navy's overall readiness as it will propose standardized solutions that adaptable to available fleet assets.

E. METHODOLOGY

This study applied an exploratory sequential mixed methods approach to its research design. First, a qualitative method was used which adopted a case study modality to evaluate processes and activities within the setting of medical departments onboard DDGs. The data derived from the qualitative results then informed the second (quantitative) phase with vital components to arrive at its phase-specific results. The integration of the qualitative and quantitative results directly addressed the research questions. The combined results also offer the study's conclusion which will address the current problem and inform future related studies.

F. SCOPE

An analysis of supply chain requirements was provided through a dual methodology approach concentrating on the implications of the COVID-19 pandemic. Moreover, this research focused on analysis and consideration toward medical supply chain practices within a specific class of destroyers (DDG), the Arleigh Burke-class. The decision to concentrate on DDGs was due to their limited size and storage capacity when compared to larger ships. Challenges to adequately supply these ships are of greater demand than their larger counterparts, such as aircraft carriers (CVN) or amphibious ships (LHD, LPD, LSD, and LCC). Changes to AMALs or any notional supply-related modifications may drastically affect operational or tactical capabilities related to storage on DDGs. Also, as a supply chain study, this thesis is not focused heavily on the clinical impact or epidemiological implications of COVID-19. Medicine or healthcare-related data will only be presented to illustrate high-level consequences of COVID-19 to affected populations and, specifically, to appreciate the pandemic's impact on operational readiness.

1. DDG

First commissioned in July of 1991 (Naval Vessel Register, n.d.), the Arleigh Burke-class destroyer (DDG) is a multifunctional guided-missile destroyer functionally designed for both independent operations and for support functions of larger strike groups (DOD, 2015). The Arleigh Burke-class was built around the Aegis and SPY-1D systems designed to identify, track, and destroy enemy targets (Benson, 1998). With an all-steel construction, this class is comprised of four categories, "Flights," starting with the original Flight I version (-DDGs 51–71), with specifications as listed in Figure 1, and continuing into the 21st century with the Flight III (DDGs 125–126) upgrades (navy.mil, 2021). The current upgrades involving Flight III, as of November of 2020, remain on schedule (navy.mil, 2020) with continued construction on 11 ships and contracts secured to 20 others indicating continued sustainment for the future of the class's vital position in the Navy's arsenal and overall force projection. This is further supported by the Navy's termination of the high-cost DDG-1000 (Zumwalt class destroyers) program, the planned replacement for the Burke's class.

ARLEIGH BURKE CHARACTERISTICS	
Displacement:	8,315 tons
Length:	504 feet (153.6 meters)
Beam:	66 feet (20.1 Meters)
Draft:	30 feet (9.1 meters)
Propulsion:	4 gas turbines, 100,000 Shaft Horsepower (SHP)
Speed:	31 knots
Range:	4,400 nautical miles at 20 knots
Manning:	346 (23 officers, 323 enlisted)
Missiles:	1 61-cell and 1 20-cell Mk-41 vertical launch system
Radars:	AN/SPY-1D multi function
Fire control:	Aegis weapon system

Figure 1. Arleigh Burke characteristics. Source: Benson (1998).

In the COVID-19 era, DDGs were one of the fleet assets directly affected by infection rates and subsequent limitations to mission-related capabilities. The Arleigh

Burke-class's inclusion in this research will inform study outcomes and provide solutions to supply chain challenges that crews may face in future pandemics.

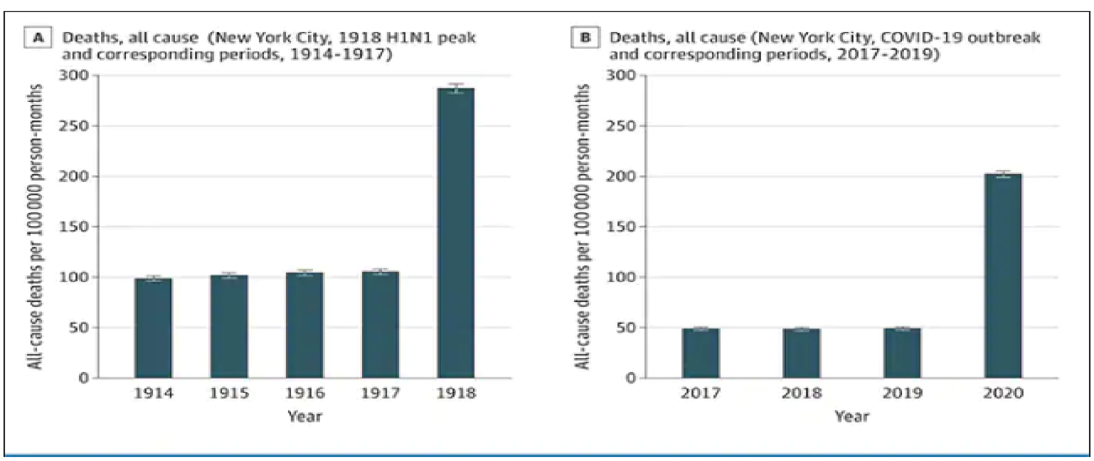
2. IDC

The Hospital Corpsman (HM) rating has been a vital part of the Navy and Marine Corps history. Depending on the setting, the corpsman has taken many different roles, including pharmacy technologist, nurse, or even a field medic in combat environments. In the latter example, many of the 2,012 (42 in Iraq and Afghanistan) recorded deaths in their history occurred (Snibbe, 2020). As a highly specialized and skilled corpsman, the IDC serves as a primary care provider and senior medical department representative across various commands. With an additional 12-month intensive training (C-School), IDCs experience a combination of didactic and clinical training focused on subjects such as Anatomy and Physiology, Clinical Lab, Chemistry, Biology, diagnostic practices, and preventive medicine (Navy Medicine Operational Training Command, n.d.). In addition to learning clinical sciences, the IDCs are also charged with learning administrative functions as many settings require enhanced responsibilities outside of clinical realms. Some of these include disaster management protocols, occupational health monitoring (Jindaet al., 2015), food service sanitation, substance abuse, pest control, and supply (Navy Medicine Operational Training Command, n.d.). The education from IDC school and follow-on training at various commands provide them with highly realistic training in preparation for combat or shipboard conditions where they will be isolated with limited medical support (Booth-Kewley et al., 2015).

G. BACKGROUND

The coronavirus disease 2019 (COVID-19) is caused by a new coronavirus not previously documented to infect humans; most infected individuals experience mild symptoms whereas others suffer severe illness and death (CDC, 2020a). This spectrum of symptoms has made effective population treatment challenging, with initial reports in the early stages of the pandemic suggesting that 20% of those exhibiting mild symptoms at onset eventually graduated to expressing severe disease including pneumonia, respiratory distress, and death in some cases (Xu et al., 2020). As of February 2, 2021, there have been

2,232,233 deaths and 102,942,978 cases globally due to the COVID-19 (WHO Coronavirus Disease (COVID-19) Dashboard, n.d.). This novel virus has presented the world with a catastrophic pandemic at a scale not seen since the Spanish Flu and, to a less comparable degree, AIDS (Spanish Flu:1918–1919 with 50M deaths; AIDS: 1981–present with 25–35M deaths) (Pitlik, 2020). In New York city state, one of the epicenters of the pandemic (McKinley, 2020), COVID-19's scale may be similar to the Spanish Flu. But, when comparing death rates from pre-pandemic times, the Spanish Flu is less significant as mortality rate ratios in the first months compared to the same periods from three previous years was 2.80 (approximately three times higher than pre-pandemic), whereas COVID-19 ratios were at 4.15 (four times higher than pre-pandemic) (Frellick, 2020.). Figure 2 shows a direct contrast of the two pandemics in relation to deaths during their first year compared to preceding years. Other sources, however, have suggested that that COVID-19 is actually a less severe pandemic compared to the Spanish Flu (El Zowalaty & Järhult, 2020). Nevertheless, the COVID-19 has proved to be a resiliently infectious disease that has continued to have severe and significant global impacts. Continued retrospective studies may provide valuable approaches to disease containment as the author identified correlative patterns, in containing infectious pandemics (Agrawal et al., 2021).



Pandemics During the Preceding Years of Both Pandemics.

Figure 2. Deaths in New York City during the 1918 H1N1 influenza pandemic and the coronavirus disease 2019 (COVID-19).
Source: Frellick (2020).

As previous historical data and accounts have demonstrated, pandemics of extreme magnitudes affect population health and trigger consequences to the world's economies (Nikolopoulos et al., & Vasilakis et al., 2021). Globally, declining consumption, decreased production, and disrupted supply chains have fostered an economic climate where a rise in unemployment was seen due to layoffs and company shutdowns (Fernandes, 2020). In the early stages of the pandemic (March, 2020), lockdowns throughout the world were implemented as reactionary measures to "flatten the curve" or to slow the spread of the disease while mitigating the burden to healthcare systems (Jenson, 2020). Government actions may have been appropriate to aggressively counter the pandemic's wider population health implications, but this meant limited forecasting were made regarding the economic recovery of their respective economies. As early as March of 2020, global markets lost $18 trillion from February's peak, seen in Figure 3 (Adinarayan, 2020), with most indices recording some of the biggest one-day declines in history, as seen in Figure 4 with the U.K. and Germany showing overall 2020 market declines of -37% and -33%, respectively (Fernandes, 2020). In the United States, the Dow Jones Industrial Average had its worst day on record at the time (March 16, 2020), as it dropped nearly 3000 points (Ping, 2020). Overall, according to Figure 5, the March 2020 domestic market declined to 30% below its peak, regressing to pre-2016 levels (Fernandes, 2020).

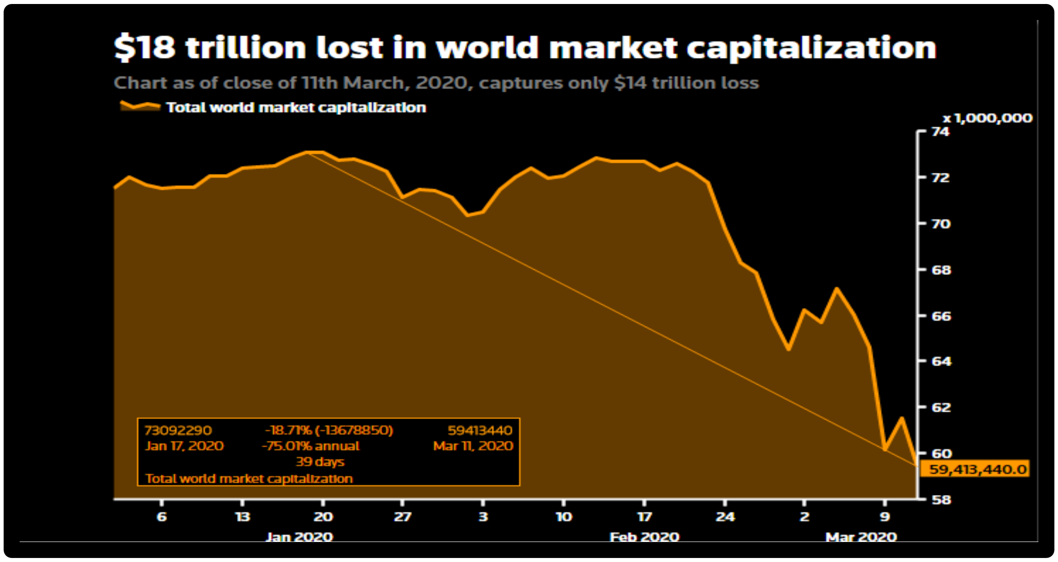


Figure 3. $18 trillion lost in world market cap.
Source: Adinarayan (2020)

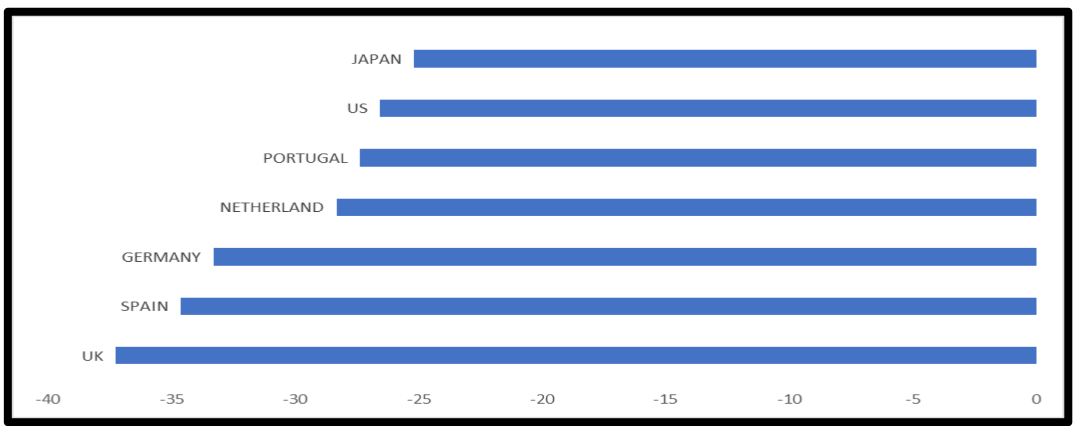


Figure 4. Stock market performance for selected countries.
Source: Fernandes (2020).

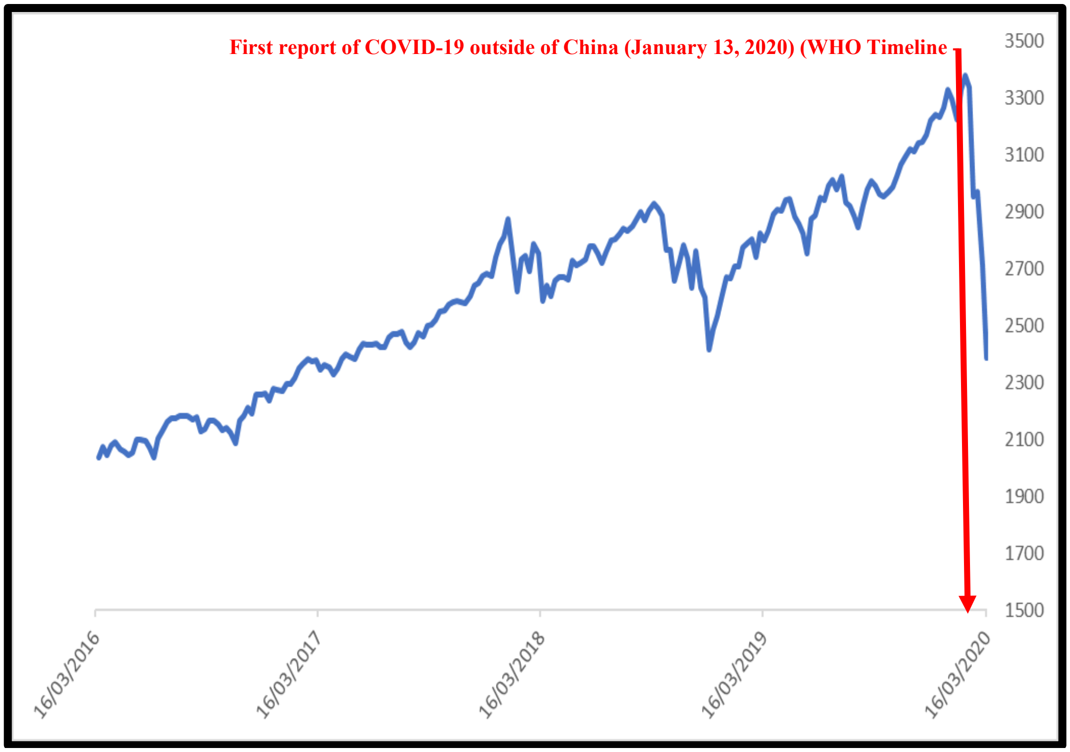


Figure 5. U.S. Stock market performance in March 2016–March 2020. Source: Fernandes (2020).

H. STUDY ORGANIZATION

This introduction, Chapter I, provides the basis for the current study as it sets the conceptual space and the background of the primary subject of COVID-19. The purpose and problem statements, the research scope, objective, and questions are also discussed in this chapter to delineate the study's parameters. Chapter I also presents and discusses the background of the study as it relates to COVID-19, and how COVID-19 impacts the world and the Navy, while also providing contextual bases of the subjects and key focuses of the study. Chapter II reviews the pertinent literature, related research scholarship, and other documents related to the study's primary subjects used to construct this thesis. This chapter also discusses the study's general direction and the purpose of sources organized thematically in subsections that address diverse aspects of the related thesis subjects or topics. Chapter III states the methodologies employed to gather and analyze data to address the research questions and problems. Chapter IV presents the data analysis and findings from the methodologies discussed in the preceding chapter, any notional inventory modifications, or any potential changes to policies that may support maintenance of optimal PPE inventories in pandemic situations. Chapter V summarizes limitations to the study and addresses the research questions. The conclusion to the thesis also details recommendations and considerations for future research.

II. LITERATURE REVIEW

The purpose of this study is to positively impact supply chain response in the next pandemic. To achieve this, research was conducted in various themes pertinent to COVID-19, supply chain, logistics, policies and PPEs. To supplement these areas, research was also performed to focus on Independent Duty Corpsmen (IDCs) and Arleigh Burke, Guided Missile Destroyers (DDGs) to provide adequate background and context to the effort's overall scope. Substantial research was also reserved for methodologies applied to address the study's purpose such as determining the Optimal Re-order Point (ORP) among others. As the literature review, this chapter will not only organize the study's general direction, but it will also familiarize readers with source typologies and the purpose in which they were used to layout the study's basis, analysis, and conclusion. Organizationally, this chapter will be arranged in thematic subsections corresponding to research areas mentioned to promote overall study structure and continuity.

A. PANDEMIC

1. Background and Historical Perspective

In setting the stage for the study, sources were selected to provide adequate background to some pandemics of the past and the impacts of the current COVID-19 pandemic on the world's societies and economies. Some medical and epidemiological sources were collected to convey disease severity at both the individual patient and population health levels for clinical perspective. The source materials were also gathered and used in this study to highlight the pandemic's impact on the U.S. military, particularly the Navy.

Historical perspective is essential in the study's context to demonstrate parallels of COVID-19 to other diseases, such as the 1918 Spanish Flu, an outbreak that is often compared to 2020s worldwide pandemic. Silvio Daniel Pitlik's medical journal article provides such comparisons while defining the term "pandemic" along with providing clinical features (Figure 6) and disease characteristics seen in Figure 7 as a basis of understanding (Pitilik, 2020). While outlining apt comparisons and chronology of pandemics, seen on Table 1, of past eras, this article concentrates on bridging the gap toward the current understanding of COVID-19 disease etiology and impact across various levels.

Disease	Salient Clinical Features
Smallpox	Typical widespread vesiculo-pustular rash, occasionally corneal opacification
Measles	Morbilliform rash, Koplik's spots, conjunctivitis, rhinorrhea
Plague	Buboes (huge lymphadenopathy), pneumonia
Cholera	Sudden-onset profuse watery diarrhea, early hypovolemic shock
Yellow fever	Jaundice
Influenza H1N1	Flu-like illness*, severe disease and death in young adults
Influenza H3N2	Flu-like illness*
Influenza H2N2	Flu-like illness*
AIDS	Opportunistic infections, Kaposi's sarcoma of skin and viscera, profound emaciation
SARS	Severe pneumonia
Ebola	Bleeding from multiple sites
MERS	Severe pneumonia
COVID-19	Severe pneumonia, silent anoxia, anosmia, ageusia, toe lesions mimicking chilblains, pediatric multisystem inflammatory syndrome

Figure 6. Leading clinical identifiers of recognized pandemic diseases. Source: Pitlik (2020).

Feature	Comments
Novelty	Mostly unknown to the medical profession
Minimal population immunity	Frequent absence of specific IgG antibodies
Explosiveness	Determined mainly by size or density of population and factors related to type of transmission, for example vector population
Fast disease movement	Type and speed of human transmission
Wide geographic extension	Social interaction of populations, widespread common source
Infectiousness	Ability of microbes to produce disease (minimal infective dose)
Contagiousness	Proportion of completely asymptomatic cases, super-spreaders, and evident and pathognomonic disease markers
Severity	Need for hospitalization, artificial ventilation, or intensive rehydration; chronicity or death

Figure 7. Eight characteristics of pandemics. Source: Pitlik (2020).

Table 1. Chronology of known pandemics. Adapted from Pitlik (2020).

Time	Name	Microbe	Death Toll
430 BC	The plague of Athens	Rickettsia spp? Salmonella enterica spp?	25% of population
165–180	Antonine plague	Smallpox? measles?	5M
541–542	Plague of Justinian	Yersinia pestis (Gram-negative bacteria)	30-50M
735–737	Japanese smallpox epidemic	Smallpox (DNA virus)	1M
1347–1351	Black death	Yersinia pestis	200M
1520-onward	New world smallpox	Variola (smallpox)	56M
1629–1631	Italian plague	Yersinia pestis	1M
1665–1666	Great plague of London	Yersinia pestis	100K
1800s+_	Yellow fever	Yellow fever (RNA virus)	100–150K
1817–1923	Cholera pandemics	Vibrio cholera (Gram-negative bacteria)	>1M
1885	Third plague	Yersinia pestis	12M
1889–1890	Russian flu	Influenza H2N2? (RNA virus)	1M
1918–1919	Spanish flu	Influenza H1N1	40-50M
1957–1958	Asian flu	Influenza H2N2	1.1M
1968–1970	Hong Kong flu	Influenza H3N2	1M
1981–present	AIDS	HIV (RNA virus)	25-35M
2002–2003	SARS	SARS-CoV-1 (RNA virus)	0.8K
2009–2010	Swine flu	Influenza H1N1	200K
2014–2016	Ebola	Ebola virus (RNA virus)	11K
2015–present	MERS	MERS-CoV (RNA virus)	0.8K
2019–present	COVID-19	SARS-CoV-2 (RNA virus)	>0.5M

Some sources in particular were cited in comparing COVID-19 to the Spanish Flu, focusing on one of the most densely populated urban areas of the world, namely New York City. The first by McKinley of the New York Times (2020) provides a narrative of the precarious plight of New York in the early stages of the 2020 pandemic, citing alarming infection rates that represented five percent of reported cases worldwide as the city prepared for lockdowns. A second source represented on Table 2 discussed specific time intervals (Spanish Flu's highest death rates: September-November versus COVID-19: March-April) as points of comparison between 1918's Spanish Flu to 2020s COVID-19 (Frellick, 2020). Frellick's article concludes that COVID-19 is "about 70% as deadly" as the Spanish Flu. This disparity is displayed in Figure 1 of the previous chapter from data collected from Center for Disease Control and Prevention, the New York City Department of Health and Mental Hygiene, and the U.S. Census Bureau (2020). To add breadth to the study and to pose contrasts to points made by some sources, this research sought to gather articles that posited COVID-19 as an even less severe (than the previously mentioned article) “pandemic threat” as the Spanish Flu (El Zowalaty & Järhult, 2020). Recent articles, however, point toward more tempered comparisons to these pandemics as data aggregation in 1918 was limited compared to 2021. The COVID-19 pandemic remains a dynamic disease at the clinical and epidemiological levels. The arguments relating to death rate data become moot in terms of medical efficacy or for the current study’s value. What are more valued approaches, when reviewing COVID-19 in parallel to the Spanish Flu, is identifying correlative patterns and strategies, such as social distancing and masks (Cheney, 2021) to contain pandemics of such magnitudes (Agrawal et al., 2021).

Table 2. Incident rate ratios for all-cause mortality. Adapted from Frellick (2020).

Pandemic Period (NYC)	Incident Rate per 100K person-months	95% CI
Peak of 1918 H1N1 influenza outbreak	287.17	282.71 - 291.69
First 2 months of COVID-19 outbreak	202.08	199.03 - 205.17

Calculation of the New York’s incidence rate per person-months for October and November (61 days) from 1914 through 1918, and for March 11, 2020, through May 11, 2020 (61 days) divided two to calculate person-months (incidents per capita per month).

2. COVID-19: Current State

The CDC and the World Health Organization (WHO) represent two agencies that provide readily accessible data as vital points of reference when researching COVID-19. Both sources provide the latest data attributing symptoms, etiology, and treatment models related to COVID-19. The CDC’s COVID Data Tracker (Figure 8), located on its website, provides a real-time source of U.S. domestic COVID-19 cases (30-day trends), total vaccinations, and total deaths (30-day trends) (CDC, 2020d). In addition to active cases and death rates, the tracker also provides valuable links to data at the community or county levels, individual hospital data, testing data, and educational tools for those at “increased risk.” Similar data could be found on the WHO’s COVID-19 Dashboard (Figure 9), which provides data on a global scale and allows users to filter to data tables showing active cases, death rates, and transmission classifications per country. Beyond the dashboard, WHO's timeline also provided temporal perspective adding to the researchers' understanding of the early stages of the pandemic's chronology from initial reports in Wuhan Province in China, to March 2020s Solidarity Trials aimed at international data aggregation to find the most effective treatments for the disease (WHO, 2020b).

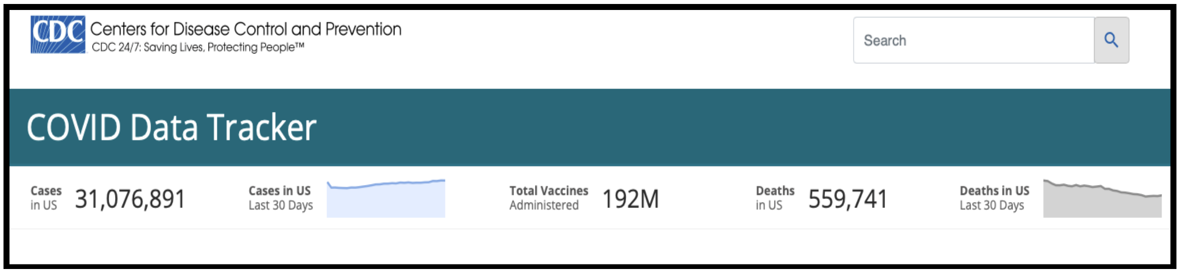


Figure 8. COVID data tracker. Source: CDC (2020b).

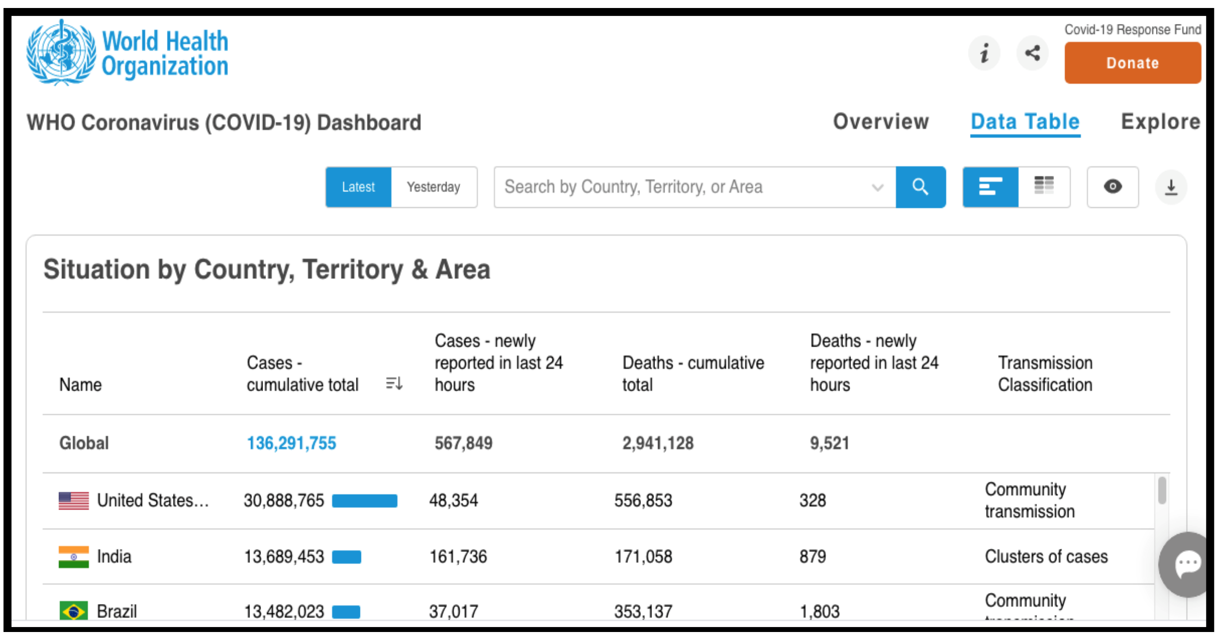


Figure 9. COVID-19 dashboard. Source: WHO (2021).

3. Socioeconomic Implications

The adverse socioeconomic effects of COVID-19 are an appropriate subject of focus for the study as these factors directly relate to the world's supply chains (Fernandes, 2020). The European Journal of Operational Research published an article providing forecasts and planning concentrating on supply chain and governmental decision making in the wake of COVID-19. This article provided a retrospective review of how the lockdowns prompted by the global health crisis triggered supply and demand consequences that caused significant disruptions of receipt of valuable materials (upstream) and the distribution of finished goods (downstream) (Nikolopoulos et al., 2021). This article's authors established the dire need for viable supply chain forecast models and offered a high-level perspective of quantifiable needs that emerge in large-scale global emergencies.

In another cited source by Nuno Fernandes, the article's author concentrates on COVID-19's effects on the global economy. Fernandes declares that although mortality rates and economic impact are noncorrelative, the COVID-19 pandemic is different due to the reactionary measures that have occurred from governments, consumers, media, and businesses which have all contributed in creating a "demand and supply shock" (2020, p. 4). This article also illustrated the global economic impact referenced in Chapter I ("Background" section, Figure 2 and Figure 3.)

4. Fleet Impact

The most widely reported case involving the Navy and the early stages of the COVID-19 pandemic has been the U.S.S. Theodore Roosevelt outbreak. The U.S. Naval Institute, on March 24, 2020, reported eight positive cases on-board (Eckstein), with later reports of at least 25% of crew members being infected at its peak according to the Center for Infectious Disease Research and Policy (Van Beusekom, 2020). These sources provided valuable data that capture early novel isolated effects to the Navy, while other sources, such as the DOD, provide more cumulative data with updated case totals, such as 37,069 cases reported for the Navy as of April 14, 2021 (Figure 10.) (DOD, 2021, Coronavirus: DOD Response).

DOD COVID-19 Cumulative Totals

	Cases	Hospitalized	Recovered	Deaths
Military	181,315	1,605	173,560	24
Civilian	50,124	1,384	44,026	224
Dependent	27,514	367	26,792	12
Contractor	17,842	500	16,361	76
Total	276,795	3,856	260,739	336

As of 0600, April 14, 2021

Army	Marine Corps	Navy	Air Force	National Guard	DOD Agencies
64,905	21,128	37,069	30,310	26,803	1,100

As of 0600, April 14, 2021

These presumptive figures are updated M-W-F and are refined as the Joint Staff Crisis Management Team receives updated/corrected reporting on case numbers.

Figure 10. Coronavirus: DOD response. Source: DOD (2021).

Impact to the fleet readiness and defense capabilities was also explored. Dunaway (2020) brought to light the delays to initial points of readiness to the military where the training environments such as boot camps and flight schools have seen delays. Another article by Commander Sam Mason (2020) offers a contrasting perspective that Navy ships, in isolation and assumed clean from COVID-19, would represent a healthier advantage compared to the broader civilian population while experiencing minimal effects to both readiness and capabilities.

As with the sources used in providing the background to the study, sources relating specifically to the COVID-19 pandemic's current state and socioeconomic implications are vital for the reader's appreciation of the weight that this crisis carries throughout the world. At its core, COVID-19 represents a health crisis, but delving into other factors that are affected, fleet impact, for example, provides the demand and justification to studies such as this.

B. PPE

Similar to the WHO and the CDC, the Occupational Safety and Health Administration (OSHA) offered readily accessible information pertinent to COVID-19, specifically regarding PPEs. OSHA covers extensive guidance on defining PPE while providing information related to standards, hazards and solutions, payment for PPEs, construction and workers' rights (Personal Protective Equipment - Overview | OSHA, n.d.). For the purpose of this study, PPEs for healthcare personnel will be the focus which include goggles or face shields, NIOSH approved N95 facepiece respirator (masks) or higher, gowns, and non-sterile gloves (CDC, 2020c). These three agencies all provide valuable content related to PPEs and their proper use (CDC, 2020c) and technical specifications (WHO, 2020a).

Beyond typology and specifications of PPEs, research into the strain placed on national stocks and inventories was also necessary to add broader context to the study. A cited article from the New England Journal of Medicine provided such context and offered perspective on difficulties of procurement of PPEs by healthcare organizations at local levels and internationally, exacerbating the crisis where some medical workforces, such as those in Italy, experienced high infection rates (Ranney et al., 2020). Compounding the challenges of procurement, a New York Times article noted that China, a key pre-pandemic supplier of PPEs (producing half of the world's facemasks), halted exports due to their own domestic challenges with infections (Bradsher & Alderman, 2020).

C. MEDICAL SUPPLY CHAIN AND LOGISTICS

As a central focus of the study, sources related to supply chain and logistics from civilian and Navy-specific policies have been included in this review. Compared to bureaucratic elements of the government, the contrasting supply chain components of the civilian sector are valid points to understand, especially with the compounding challenges that COVID-19 presents. The enterprise levels of the government supply chain system, including contracts (multiple awards vs. sole source), contracting officers, simplified procurements, and implications of purchases over $25,000 (Bame, 2019), all contribute to many inherent challenges to how the DOD maintains inventory of supplies. To add to these challenges, COVID-19 brought accelerated demand for military air components to bring supplies in-country to mitigate challenges stemming from halted commercial flights (Lopez, 2020).

In this study, some of the concentration points regarding policies and processes related to supply chain practices will revolve around NAVMEDLOGCOM. NAVMEDLOGCOM shares the responsibility of managing medical and dental assemblages (including PPEs) and represents the conduit in assemblage content reporting throughout the Defense Medical Logistics Enterprise (DMLE) (*COMUSFLTFORCOM_COMPACFLTINST_6700.1*, 2015). As the Navy's medical logistics command, NAVMEDLOGCOM navigates the DOD's supply and logistics enterprise through sound policies and constant collaborations with partner agencies such as Defense Health Agency Medical Logistics (DHA MEDLOG), U.S. Army Medical Material Agency (USAMMA), U.S. Army Medical Research and Material Command (USAMRMC), Air Force Medical Operations Agency (AFMOA), and us Marine Cops System Command (MARCOSYSCOM) (What's the buzz. n.d.).

D. SUMMARY

This chapter offered a review of existing literature and scholarship within the realms of the COVID-19 pandemic, its global impact, and its implications to the Navy's fleet. Sources more central to the study's focus were also included in this review. The author discussed supply chain and logistics as they pertained to the civilian sector and DOD-specific material. Regarding the scope, literature that informed the study of the background of DDGs and IDCs was also reviewed to provide relevant background. Lastly, literature related to the study's methodology and design was reviewed as a preamble to the following chapter which explains our approach and methodology.

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III. METHODOLOGY

This chapter discusses the research approach taken by the author and how the selection of the research design is justified in addressing the two research questions. A dual approach, mixed method, is employed for this study, and the author will detail the reasoning behind this approach. Specifically, the author will detail each method; how the integration of the qualitative method used and the theoretical grounded ROP, the quantitative method, benefits the study by providing a broader understanding of the current problem. Further discussion is also included to describe analytical processes and data gathering methods that form the results and subsequent conclusions of this study.

A. RESEARCH APPROACH

To address the purpose and research questions, research will dictate gathering pertinent policy data concerning supply chain, Navy-wide guidance concerning pandemic preparedness, and CNSP After-Action Reports and Lessons Learned from the COVID-19 pandemic to understand likely usage rates and compare them with on-hand inventory. Secondly, the author will examine potential PPE shortages to the fleet by describing the impact of COVID-19 response within the DDG (Arleigh Burke-class) platform and the process of PPE procurement, inventory tracking & management, and AMAL modifications at the fleet level. Data was collected using information-gathering interviews to identify ineffective supply chain practices at the medical department level to better inform training and operating procedures at fleet and enterprise (Navy Medicine, NAVMEDLOGCOM, CNSP, DHA, and DOD) levels. Further examination of PPE "expenditure rates," specific to DDGs, will also be conducted to appreciate any significant trends that may contribute to suboptimal care or practices that may occur during future pandemics. A similar study applied the expenditure rates data in regression analysis to forecast optimal on-hand PPE supplies on DDGs to deliver care and optimally minimize infections safely. Comparing the current study's results with this study will be conducted to avail stakeholders to varying forecasting methods to employ in situations they deem adequate.

This study seeks to examine and improve COVID-19 response at the ship and fleet levels by evaluating notional modifications to authorized medical shipboard allowances, medical supply chain processes and policies to increase resiliency for future pandemics. To accomplish this, policy data was gathered related to the required shipboard Authorized Medical Allowance List (AMAL), including consumable supplies, which are presently tailored toward mass casualty situations, and not pandemics. Guidance from OPNAV, PACFLT, Fleet Forces, and Navy Medicine guidance regarding pandemic preparedness and response was also examined. The initial findings were then integrated with the AMAL review processes. The data were brought together with CNSP After-Action Reports and Lessons Learned from the COVID-19 pandemic to understand likely usage rates and compared with on-hand inventory. Additionally, interviews with Subject Matter Experts (SME) were conducted to better appreciate the dynamic nature of provisioning healthcare while maintaining adequate medical supplies in shipboard settings. This research was also guided by a mathematically based reorder point (ROP) model along with a regression analysis. Both modes of study aimed to present more efficient PPE inventory replenishment practices that may positively impact the fleet's on-hand inventory readiness and the Navy's ability to accomplish recommended levels of resupply.

B. RESEARCH DESIGN

The initial theoretical approach for this study focused on quantitative methods bound to resolutions that improve upon the PPE supply chain in pandemics. Specifically, the research was driven by requirements to evaluate notional modifications to general shipboard AMAL inventory. With proposed changes from the AMAL Modernization Review in November of 2020, PPE items were increased or added to shipboard inventories to support future pandemic response (Department of the Navy, 2021). These changes are seen in Figure 11, which is the third enclosure to Modernization Review. Due to these modifications, the current study narrowed its scope to focus on a specific ship class, the Arleigh Burke DDG, to aid in determining tracking solutions and automated ad hoc reorder models germane to PPEs. This change in focus aims to mitigate shipboard PPE supply challenges during high-demand or dynamic circumstances such as those that occur during pandemic scenarios such as COVID-19. A quantitative analysis of PPE expenditure rates was needed to propose modeled inventory reorder innovations, but further exploration practices were needed to form solutions that aid frontline IDCs to track PPEs efficiently. The need for further exploration necessitated the employment of a mixed-methods approach. In this study, quantitative and qualitative data are used to answer the research questions and, more importantly, converge results (Jick, 1979) to form solutions that address real-world supply challenges.

6510005593163 (PACKING WOUND 5YDX2IN COTTON GAUZE CURITY MESH SELVAGE EDGE PLAIN S	
Removed from assemblages as Iodoform is the standard for wound packing and is more cost efficient.	6510005593163
6510015418121 (DRESSING WOUND 6IN EMERGENCY ABDOMINAL)	
Removed from FAB/GB/BOAT BOX AMALs only due to Abdominal Evisceration Injury removed IAW TCCC? guidelines.	6510015418121
6515013615228 (SHIELD FACE SPLASH24S)	
Item added to AMAL to aid in Health Force Protection instead of creating a Pandemic AMAL.	6515013615228
Added as Covid support	6515013615228
6515014915719 (GLOVE PATIENT EXAMINING & TREATMENT SZ 10LG PURPLE 4.3MIL 100S')	
increased number to accommodate basic need.	6515014915719
6515015369363 (INTRAOSSEOUS UNIT INFUSION, EZ-IO STERNA)	
Item is replaced by the Arrow EZ-IO, as the current product has a separate drill and the new drill is universal, and the preferred product.	6515015369363
6515016487346 (SET NEEDLE 25MM 15GA EZ-IO EZ-CONNECT NEEDLE VISE EZ-STABILIZER STAINLE	
Added as support item for new IO Gun	6515016487346
6515016487352 (SET NEEDLE 45MM 15GA EZ-IO EZ-CONNECT NEEDLE VISE EZ-STABILIZER STAINLE	
Added as support item for new IO Gun	6515016487352
6532016853422 (GOWN SURGICAL DISPOSABLE AERO CHROME LARGE STANDARD PERFORMANCE	
Item added to AMAL to aid in Health Force Protection instead of creating a Pandemic AMAL.	6532016853422
6840015422011 (WIPE DISINFECTANT 160 WIPE NONWOVEN CANISTER CAVIWIPES 6.75X6IN)	
Item added to AMAL to aid in Health Force Protection instead of creating a Pandemic AMAL.	6840015422011
8465013376792 (TAG ID PERSONNEL CARDBOARD 8.188INX4.062IN FIELD TRIAGE 50S)	
To be replaced with form DD1380 IAW TCCC standards	8465013376792
Remove from Gen Med and replace on BDS and MCB with 1380 NSN for 100's and all other Kits with 1380 NSN for 10	8465013376792

Encl: 3 of November 2020 AMAL Modernization Review.

Figure 11. November 2020 Surface Force Independent Duty Corpsman Authorized Medical Allowance List Modernization Review. Source: DON (2021).

C. MIXED METHOD DESIGN

Creswell's book on research design was the foundation from which this study's author gathered material to formulate the study's methodology and determine the research approach: quantitative, qualitative, or mixed methods (Creswell, 2014). Early opinions on mixed methods were that the combination of quantitative and qualitative data would nullify any biases or weaknesses of each method (Creswell, 2014). This study employs a sequential approach as it gathers qualitative data first to inform or build upon the quantitative phase. These research phases will then culminate in a third and final phase to integrate data (Berman, 2017) that ultimately address the research problem. This model is called an Exploratory Sequential Mixed Methods (Creswell, 2014) model, and it is the basis for the order and organization of the study.

D. QUALITATIVE METHOD AND RESEARCH PROCESS

The objective of the qualitative method used in this study is to understand processes at a supply chain endpoint from the perspective of the IDC. Specifically, tracking and policy mechanisms are explored to appreciate limitations that may be mitigated or improved. A main attribute of the qualitative phase is to address the first research question (Table 3.).

Table 3. Research question 1

How can the Navy provide frontline Subject Matter Experts (Independent Duty Corpsman—IDC) the means to efficiently and accurately track PPEs during COVID-19 type pandemics?

The realized improvements of tracking practices resulting from the themes identified in the interview design might, then, positively affect reorder innovations proposed by the quantitative results. In this case, the benefits of accurate tracking would lead to a standardized method of forecasting or reorder points.

As the study evolved, interviews were vital components in gathering background information concerning policy and gathering primary data from SMEs. Along with the existing research design literature, sources interview methods, advantages and limitations were considered, as seen in Figure 12. In gathering data from the SMEs, interview protocols were formulated and managed to include observation techniques, medium(s) of transcription, styles of transcription (Creswell, 2014) and considerations of reflective notes including "speculation, feelings, problems, ideas, hunches, impressions, and prejudices" by the researcher (Bogdan & Biklen, 1992, p. 121). These examples that deal with perceptions of the researcher may also pose as limitations to the study, which will be discussed in the final chapter. To balance these limitations, further guidance from the literature was essential in determining a qualitative methodology as the interview approach explored and attempted to understand objective individual (subgroup: IDCs) processes as they adhere to policies in their settings (shipboard) (Creswell, 2014).

Data Collection Types	Options Within Types	Advantages of the Type	Limitations of the Type
Observations	• Complete participant—researcher conceals role • Observer as participant—role of researcher is known • Participant as observer—observation role secondary to participant role • Complete observer—researcher observes without participating	• Researcher has a firsthand experience with participant. • Researcher can record information as it occurs. • Unusual aspects can be noticed during observation. • Useful in exploring topics that may be uncomfortable for participants to discuss.	• Researcher may be seen as intrusive. • Private information may be observed that researcher cannot report. • Researcher may not have good attending and observing skills. • Certain participants (e.g., children) may present special problems in gaining rapport.
Interviews	• Face-to-face—one-on-one, in-person interview • Telephone—researcher interviews by phone • Focus group—researcher interviews participants in a group • E-mail Internet interview	• Useful when participants cannot be directly observed. • Participants can provide historical information. • Allows researcher control over the line of questioning.	• Provides indirect information filtered through the views of interviewees. • Provides information in a designated place rather than the natural field setting. • Researcher's presence may bias responses. • Not all people are equally articulate and perceptive.
Documents	• Public documents—minutes of meetings or newspapers • Private documents—journals, diaries, or letters	• Enables a researcher to obtain the language and words of participants. • Can be accessed at a	• Not all people are equally articulate and perceptive. • May be protected information unavailable to public or private access.

Figure 12. Qualitative data collection types, options, advantages, and limitations. Source: Creswell (2014).

In compliance with Naval Postgraduate School's (NPS) Human Research Protection Office & Institutional Review Board (IRB), the student researcher and principal investigator submitted a Human Subject Research Determination Request (Appendix A.). As this study involved interviews, this determination was needed to determine if it met the IRB's criteria as a study involving human subject research. The response to the request was an IRB determination that the study did not involve human subject research and did not require further approval from the IRB or the NPS president (Appendix B).

Moving past the IRB determination, the research process for the qualitative phase, then, hinged upon four factors: crafting a study design, creating the questionnaire, conducting interviews, and analyzing data from responses. All four factors were vital in this phase and within each, there came sub-processes that were required for phase completion and the subsequent transition into the second phase, the quantitative ROP phase.

1. Case Study Design

The case study design is one of the most widely used research methods across academic realms (Yazan, 2015). Case studies focus on collecting data through inquiries or evaluations of programs, activities, processes or events (Creswell, 2014) over a period of time (Yin, 2012). This design selection is appropriate for the current study due to its qualitative component's inquiry into the IDC's activities and processes as they maintain medical supply inventory. These processes and activities were also limited to a specified time range, underway onboard DDGs.

2. Interview Process and Questionnaire

Participants were solicited for participation via IDC specialty leaders and contacts from NAVMEDLOGCOM. There were seven willing participants identified. Along with a formal introduction of the study purpose and scope, participants were also assured that their personal information would not be shared outside of the interview. Due to ROM to naval personnel during the pandemic, the researcher used phone interviews and Zoom sessions to gather data. Between December of 2020 and February of 2021, interviews were conducted with questionnaires via email in cases where phone service was unreliable (due to remote locations or deployment requirements). Interview sessions were scheduled for 30-minute slots, but an additional 30 minutes was also reserved as needed.

The questionnaire was designed to elicit objective responses regarding standard practices, processes, and policies. Questions were not designed to induce subjective or opinionated views of the IDCs. Although they were free to discuss professional opinions, the researcher made clear that only non-subjective data gathered pertaining to the core questions would be transcribed and analyzed as part of the study. A sample of the questionnaire is found on Appendix C, but the core questions found in Section 2 of the questionnaire will be referred to and discussed to understand its purpose as it relates to the study.

The top of the questionnaire offered a standard introductory greeting to initiate the interview process. It provides the interviewees a general understanding of how responses will be used for the study. This introductory greeting was stated for each interview to promote standards of practice for all participants. Section 1, offers general questions to gather background information regarding demographics and career history. Regarding Section 2, the core questions of the qualitative phase of the study, the questions' overall purpose was to gain a broad understanding of supply chain support or guidance from an IDC's pre- and post-pandemic perspective. As a collective, the core questions were aimed at gathering data that would infer solutions to addresses the first research question and its focus on providing IDCs efficient means of managing PPE inventory. The purpose of each question is outlined in Table 4 below.

Table 4. Questionnaire purpose

Core Questions	
Questions	**Purpose**
1. Who (person/organizational entity/POC) provides you supply chain (inventory ordering, tracking, storage) support or guidance underway and pier side?	To identify source of direct or non-direct supply chain support and guidance.
2. What was the 'burn rate' of PPE during deployments (during and pre COVID-19 Pandemic)?	The understand the level of situational awareness regarding PPE usage during deployments and to inform the quantitative phase with consumption rates (burn rate)
3. What was the 'burn rate' of testing kits during COVID-19 Pandemic?	The understand the level of situational awareness regarding testing kits usage during deployments (Included in the case the scope widened to include testing kits).
4. What policies/instructions provide guidance to maintain supplies?	To understand general knowledge of and sourcing of policies and instructions.
5. What policies/instructions provide guidance to maintain supplies (tracking and management) during the COVID-19 Pandemic.	To understand general knowledge of and sourcing of policies and instructions that may have been used during the pandemic.
6. What type of didactic or follow-on training was provided as the primary manager (IDC school or other)?	To gauge the level of training provided to IDCs prior to independent practice.

3. Data Collection and Analysis

The qualitative data collected during the interview process was transcribed and aggregated on Microsoft Excel software. This mode of data collection allowed for the identification of themes, creation of codes and yielded quotes from the responses upon analysis. On a separate worksheet ("Data Aggregation, Review and Analysis") from the actual individual questionnaires, each question was spread out in order on columns with corresponding responses from each participant listed below in successive rows. This method allowed means of reviewing all responses for each question facilitating recognition of common themes and quotes. Upon recognition of saturated divergence or concurrence amongst the responses, an inference was made and themes were noted on the bottom of the worksheet. This process of theme recognition and subsequent note transcription was repeated for each question. These notes would be the foundation of identifying themes across responses.

This study focused on common themes to address the first research question and, to some degree, leverage quotes to identify variables used in the quantitative phase. In this case, expenditure rates or usage rates from question 2 of the questionnaire was a focal point in determining a variable component to the ROP equation applied in the second phase of the mixed-method study.

As COVID-19 presents many novel challenges, the current research adopted an emergent design that enabled the researcher to apply inductive and deductive analysis. Inductively, this was done by analyzing themes from objective data from the interviews while also incorporating the data collected from subjective reports (lessons learned and after-action reports). a continuous review of the themes gathered was conducted in determining saturation levels of informative data (Creswell, 2014). In this case, data from the interview processes was determined to be sufficient towards building upon the quantitative phase and for proposing study results and conclusion.

E. QUANTITATIVE METHOD

A different sampling technique was employed for the second phase of the mixed-method study as it addressed the second research question (Table 5.). This phase builds on results gathered from the qualitative phase, particularly the second of the core questions mentioned, concerning expenditure rates. This average number deduced from the question provided an instrument from which to assume an essential variable in applying the ROP and its equation, the expenditure rate or the average number of units consumed daily. In addressing the second research question, this study opted to employ the Reorder Point (ROP) model to determine the optimal onboard quantity of PPEs.

Table 5. Research question 2

How can the Navy determine a reasonable onboard allowance for pandemic-related PPE given limits on shipboard storage and Authorized Medical Allowance List (AMAL) composition and an empirically-sound prediction for the usage rate of each category of PPE during a pandemic?

1. Applying the Reorder Point (ROP) Formula

The actual ROP, or what some call a continuous review system (Bergvall & Bjorkman, 2006), is a quantity or inventory level which coincides (triggered) with an executed order for additional units, replenishing stocks to mitigate backorders (Chen, 1998). A challenging aspect of the Navy's PPE supply chain during the COVID-19 pandemic, or in the fleet's usual dynamic nature for that matter, is replenishment when demand or usage rate (burn or expenditure rate) and lead times are uncertain. Applying a fleet-based supply chain ROP model where logistical assumptions are applied should mitigate shortages.

The standard ROP formula is demand during lead time + safety stock (SS). The first component of this formula (demand during lead time) is the product of the average daily demand or expenditure rate (d) and lead time (l). The lead time is the average total time between order placement and receipt of the ordered product (Lopienski, 2019). For example, if the average expenditure rate of N95 masks on a fictional ship, DDG X, was 3 per day (30-day period) and the average lead time, according to 10 orders, is 15 days, the demand during the lead time would equal 45.

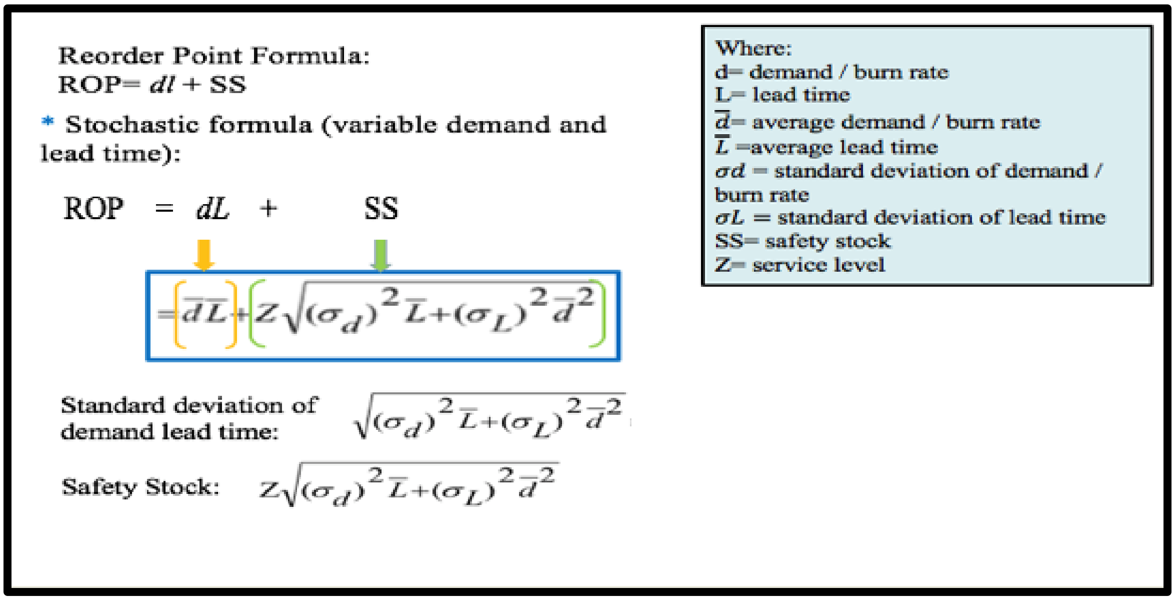
An additional factor that would benefit onboard inventory management is a critical ROP element called the safety stock, which, along with the overall ROP model, represents optimal value points to prevent over or to understock (Aljanabi & Ghafour, 2020). Another vital attribute is that it represents a quantity of extra inventory maintained in anticipation of variable supply, demand, and lead time (Lopienski, 2019). Underway, DDGs will have high variability of lead time depending on the ship's location, length of deployment, location, or availability of products (prepositional stocks or land-based distributers). The process to determine the safety stock is shown in Table 6.

Table 6. Safety stock (SS) formula

The number of maximum burn rate (single day) multiplied by maximum lead time.
Average daily burn rate (E) multiplied by average lead time (LT).
Subtract task 2 from task 1 or SS = (max d * max l) - (E * LT).
• Example SS of N95 masks on DDG X: SS = (30 * 40) – (15 * 18) = (1200) – (270) = **930**

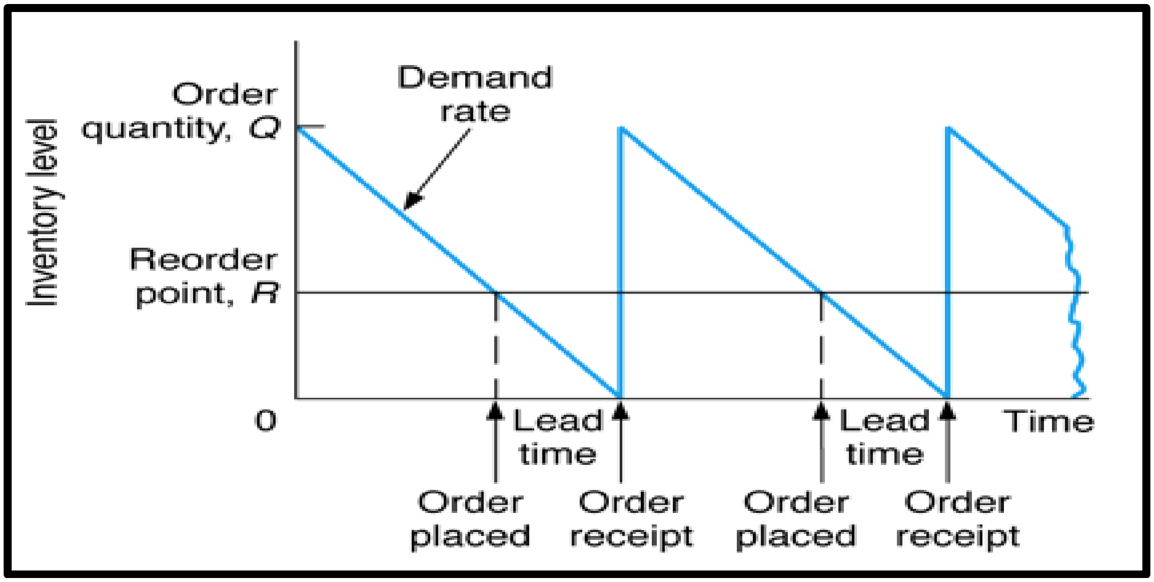
The average numbers in the formulas and examples were used due to the selected version of the ROP formula. This version considers variable expenditure rates and lead times, similar to situations that come with highly mobile entities in dynamic environments or times. This is the case with supply chains involving such items as PPE in pandemics situations.

Some of the variables shown in Figure 13 below will derive from the questionnaire presented to the IDCs and assumptions based on logistics and geography as it pertains to challenges faced when DDGs are underway. Again, question 2 elicited responses attempting to inform this phase with expenditure or "burn" rate. The figure will also review all formulas discussed and culminates with the formula employed to produce the second study phase results. The formula circled in blue represents the stochastic model of the ROP, where variable (random and unknown) expenditure rates and lead times are accounted for, unlike the standard deterministic model, which reflected known and constant expenditure rates and lead times (Maiti et al., 2009). The contrast between these inventory modeling types is represented in Figures 14 and 15. Figure 14 shows a deterministic model, presented with a smooth saw tooth appearance indicating continuous inventory maintenance and a triggered reorder point when a predetermined inventory level is met. Figure 15 represents a more appropriate stochastic model for the current study as lead time and demand are uncertain. The more jagged saw tooth appearance represents unstable forecasting metrics which would require increased safety stocks to negate stockouts (California State University, Northridge, n.d.).



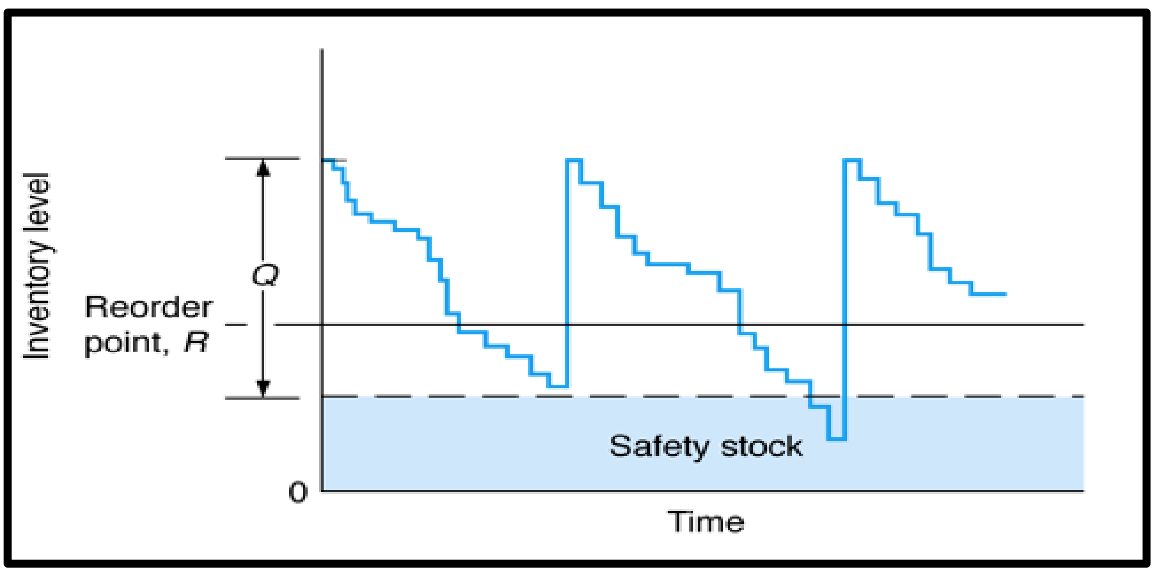
ROP Formulas and variables reference.

Figure 13. ROP formulas and variables reference. Adapted from California State University, Northridge (n.d.).



Ideal and more stable model.

Figure 14. ROP continuous system: Deterministic model. Adapted from California State University, Northridge (n.d.).



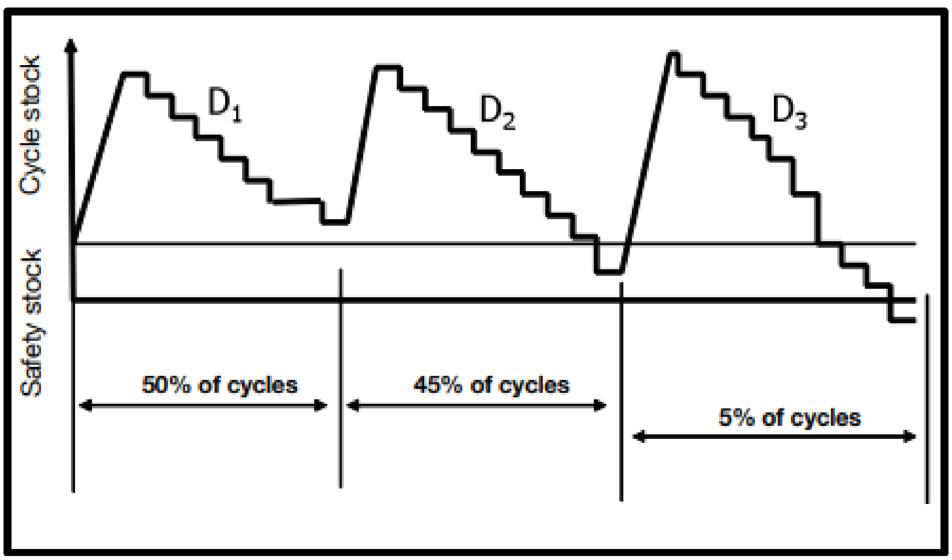
Less ideal and less stable model, but provides a more realistic and appropriate model to employ in the second phase of the study.

Figure 15. ROP continuous system: Stochastic / non-deterministic model. Adapted from California State University, Northridge (n.d.).

Determination of safety stock may not always prevent stockouts, but a model that implements service levels with corresponding Z-scores (Z factor) will allow for supply chain designs that better controls for more favorable probability of stock-outs (King, 2011). With a Z-score of 1.65, the expectation is that there will be sufficient inventory at 95% of the time. In this example, 95% is the desired service level that organizations set as benchmark or as standards. These Z-scores can be found in readily accessible tables, seen in Figure 16, or can be calculated using Microsoft Excel's 'NORM.S.INV' function with a given service level percentage (Figure 17).

Desired cycle service level	Z-score
84	1
85	1.04
90	1.28
95	1.65
97	1.88
98	2.05
99	2.33
99.9	3.09

Figure 16. Service level and Z score table. Source: King (2011).



In this example, an inventory is set at a 95% service level. The probability is that 50% of the time the stock will not be depleted while the safety stock will not be affected. For the next lead time cycle there is an expected 45% of the stock will not be depleted. But it is estimated that in 5% of the cycles, there can be an expected stockout.

Figure 17. Inventory set for a 95% service level. Source: King (2011.).

F. METHODOLOGY SUMMARY

As a study on an emerging subject, the pathway to results did not come through a prescribed or tightly codified methodology. Elements of the study were changed during and after data was gathered. In the qualitative phase, questions were changed from a focus on broad notional AMAL inventories to a shipboard supply chain management focus. The key and fundamental concentration of the first phase of learning about the PPE problem from the participant perspective, however, remained the same. The second, quantitative, phase will sample results from the first phase. Specifically, the expenditure rate (d or $\overline{d}$) from question 2 of the questionnaire will be applied to the ROP formula. The remaining variables will be based on assumptions related to medical logistics while underway.

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IV. ANALYSIS AND FINDINGS

A. QUALITATIVE INTERVIEW RESULTS

Due to the different ways with which participants responded, it was essential to concentrate on common themes that could be identified upon reviewing all responses. Some participants provided simple one-, two- or three-word answers, while others were more thorough and descriptive with their responses. Focusing on identified common and important data from responses was key toward efficient analysis. This process of “winnowing” important data while disregarding other parts of the responses was essential in data aggregation and grouping them into common themes (Guest, MacQeen, & Namey, 2012). Longer responses were truncated to isolate key words.

Common answers would indicate themes of commonality which may be interpreted as indication of strong standardized understanding or practices by the IDCs as they managed their respective inventories. Concurrence may also represent common themes of limitations or deficiencies with regards to processes or practices. Variation of answers would indicate limited or lack of continuity with regards to perception, knowledge or processes. Recognition of these divergent responses would not indicate deficiencies on the part of the IDCs, but simply weak points of standardization which may contribute to general inefficiencies to supply management. The perceived commonalities or concurrence along with divergent responses were analyzed and are presented in Table 5. Response data on the table are listed after the winnowing, coding and truncation process so only key phrases will be revealed.

Table 7. Questionnaire results

Core Questions Results **Questions:**	**Identified Common Responses (Concurrence or Divergence)**
1. Who (person/organizational entity/POC) provides you supply chain (inventory ordering, tracking, storage) support or guidance underway and pier side?	• COMNAVSURFPAC/SURFOR Atlantic • ISIC (Immediate Supervisor in Command) • NAVMEDLOGCOM • TYCOM • SAILOR • AMAL Review Board • Other IDCs
Concurrence: Strong concurrence with all respondents identifying the following: "COMNAVSURFPAC" / "SURFOR ATLANTIC," and "TYCOM." Other responses exhibited concurrence on a less significant scale with some respondents identifying "other IDCs" (4), "R Supply" (3), "NAVMEDLOGCOM" (3), "AMAL Review Board" (3) "Force Surgeon" (2), "SAILOR" (2), and "ISIC" (Immediate Supervisor in Command) (2). This result implies a strong understanding of the chain of command and sources of medical supply chain management guidance amongst the respondents. This may also imply effective promulgation of information and guidance from higher echelons of fleet leadership from the COMNAVSURFPAC/SURFOR Atlantic, and TYCOM levels. This result may suggest strong continuity of perceptions and may promote standardized practices when operating in an independent capacity.	
2. What was the 'burn rate' (expenditure) of PPE during deployments (during and pre COVID-19 Pandemic)?	• NOT deployed/No burn rate response provided (3). • Most used: Gloves 200/month; **N95 200/ month.** • Gloves: 200–300 boxes of gloves • **N95 300**. *NOT actual number but estimation. • **N95: 100/month.**
Divergence: There weak concurrence exhibited amongst all respondents. All responses were unique and showed significant divergence of reported or perceived expenditure rates of PPE. As this particular question is highly relevant to the study, as it was designed to inform the second phase of the study with the 'demand' variable of the ROP formula, assumptions will be required to fulfill this purpose. Moreover, 42 percent of respondents did not provide data as they were not underway during the pandemic or could not recall. ****Due to the limited results the estimated average amongst the 3 relevant responses are taken, which in this case, is N95 with an average of 200 units / month. This data point will represent the instrument providing the vital variable for the ROP formula employed for the second phase of the mixed method study. ****	

Core Questions Results

Questions:	**Identified Common Responses (Concurrence or Divergence)**
3. What was the 'burn rate'(expenditure) of testing kits during COVID-19 Pandemic?	• NOT deployed/No burn rate response provided. (6) • No testing capabilities prior to 20 April 2020, including during first medevac period involving possible COVID-19 infection(s).
Concurrence: Although the results from this particular question exhibited an extremely high concurrence. The commonality of respondents was mainly due to the fleet's limited supply or due to respondents non-deployed statuses. Only one respondent reported testing kit data, however due to the scope of this study, this question did not contribute to the overall results. Data from the accounts of the respondent, however, is best suited for future studies involving test kit supply chain management.	
4. What policies/instructions provide guidance to maintain supplies?	• COMNAVSURFORINST 6000.1. • Fleet Forces supply management guidance. • NAVMED P5010 PREVMEND MANUAL. • NAVSUP Manual. • Message traffic. • NAVMEDLOGOCM quarterly updates.
Concurrence: There was strong concurrence across all responses appearing to exhibit standard reference points as sources of medical supply chain guidance. COMNAVSURFORINST 6000.1 was a common response amongst all respondents, while NAVMEDLOGCOM (4) updates, (3)Fleet Forces (3), and NAVSUP Manual (3)all representing other common responses. Similar to the first question, the strong concurrence amongst responses may also imply shared perception and understanding of policy sources regarding medical supply chain management.	
5. What policies/instructions provide guidance to maintain supplies (tracking and management) during the COVID-19 Pandemic.	• Force Surgeon, SURFPAC (Inconsistent tracking requirements). • PACFLEET • COVID-19 PPE Supply instructions. • Message traffic. • DESRON • 7th Fleet • TYCOM
Concurrence: There was some degree of concurrence amongst responses, but exhibiting less concurrence than question 1 or 4. Of the common resulted responses, "message traffic" (5) was the main source of policy guidance during the pandemic, followed by "Force Surgeon" (3), "COVID-19 PPE" supply instructions (2), "DESRON" (2), "TYCOM" (1) and "7th Fleet" (1). The dependence on message traffic may have been due to the novel and dynamic nature of COVID-19 and the fleet's reactionary responses based on CDC guidelines and developing science or scholarship. Those that cited the Force Surgeon, TYCOM, DESRON, or 7th Fleet perceived inconsistent promulgation of inventory and tracking requirements with divergent perceptions of inventory frequency (responses ranged from daily, weekly, bi-weekly, or when requested). Three respondents stated some confusion due to multiple disseminated spread sheets required for report PPE inventory.	

Core Questions Results	
Questions:	**Identified Common Responses (Concurrence or Divergence)**
6. What type of didactic or follow-on training was provided as the primary manager (IDC school or other)?	• 2-day course (TMIP AND SAMS introduction and system navigation). • Brief supply chain simulation. • DMLSS (follow-on) • Verry little / No training provided.
Concurrence: There was significant concurrence across all responses appearing to imply poor training standards during didactic (IDC School, SWMI). and follow-on fleet-based training. The most common response, which appeared to be a convergent sentiment, was "Very little / No training provided" (5), followed by "2-day course" (2), "Brief supply chain simulation" (1), and DMLSS (1). This indicates a limited supply chain knowledge base for the IDCs which may adversely affect their supply management capabilities as they operate at an independent capacity.	

1. Phase 1: Qualitative Summary

The core question results can be isolated into three different groups: Positive (those with identified themes and results that imply or suggest positive and sustainable attributes in supply chain management), Negative (those with identified themes and results that imply or suggest limiting or deficient factors in supply chain management), and Inconclusive (limited or irrelevant results that fail to meet or exceed the bounds of the study scope.)

The positive results derived from questions 1, 4, and 5 (Table 8.). These questions aimed at gauging the respondent's perceptions and understanding of medical supply chain guidance from sources within their expanded chain of command, fleet resources, policies, and instructions. Responses in these core questions resulted in significant concurrence where some responses (Question 1: "COMNAVSURFPAC" / "SURFOR ATLANTIC," and "TYCOM"; Question 4: "COMNAVSURFORINST 6000.1" and "NAVEMEDLOGCOM"; Question 5: "message traffic") met significant saturation levels that may indicate strong continuity and understanding of processes, policies and sources of guidance related to supply chain management amongst the IDC respondents. Question 5, although resulting in strong concurrence, also suggested some lack of continuity at the higher levels echelons (TYCOM, COMNAVSURFPAC, SURFOR ATLANTIC, DESRON) where PPE tracking requirements were promulgated as 3 respondents stated confusion as to expectations of frequency of PPE inventory and medium of tracking (multiple circulating spreadsheets).

Table 8. Core questions: Positive results

1. Who (person/organizational entity/POC) provides you supply chain (inventory ordering, tracking, storage) support or guidance underway and pier side?
4. What policies/instructions provide guidance to maintain supplies?
5. What policies/instructions provide guidance to maintain supplies (tracking and management) during the COVID-19 Pandemic.

The negative results derived from question 6 (Table 9.). This question aimed at gauging the level of training the IDCs received prior to independent operations. The significant concurrence in this case may indicate a strong consensus amongst 5 responses of "Very little / No training provided." The limited training mentioned by respondents include a 2-day supply chain related course (TMIP AND SAMS introduction and system navigation) and a supply chain simulation. One response implied a substandard mode of supply chain training. These negative results may indicate areas of potential improvement in supply chain training at the formal didactic level, conducted in IDC School, and at follow-on training opportunities.

Table 9. Core questions: Negative results

6. What type of didactic or follow-on training was provided as the primary manager (IDC school or other)?

Inconclusive results were derived from questions 2 and 3 (Table 10.) and gauged the level of situational awareness regarding expenditure rates of PPE and COVID-19 test kits, respectively. Question 2 resulted in only 4 responses that provided PPE expenditure rates and will inform the second phase of the study with the average expenditure rate of N-95 as a variable in the ROP formula. The average (200 units / month) number is taken from the limited responses of 100, 200, 300 units consumed per month. Question 3, provided little data and can be used in future studies where the scope incorporates COVID-19 testing kit expenditure rates.

Table 10. Core questions: Inconclusive results

2. What was the 'burn rate' of PPE during deployments (during and pre COVID-19 Pandemic)?
3. What was the 'burn rate' of testing kits during COVID-19 Pandemic?

All core questions had their specified purpose in analyzing the case study from a holistic perspective regarding PPE supply chain management on DDGs. Questions were posed to elicit responses that could be aggregated and induce implications that addressed the first research question (Table 11.) This was achieved through identification of strong attributes of current supply chain practices and understanding the knowledge base among respondents. These identified attributes suggest points of sustainment that may contribute to accurate and efficient PPE inventory management in future pandemics. Of equal importance was identification of converging responses that implied training deficiencies (Question 6). This recognition may address a point of enhancement in IDC school curriculum regarding supply chain management. Overall, the research question was addressed by providing proposed solutions of providing IDCs the means to effective supply chain management by recognition of and proposed sustainment of effective practices and identifying likely shortfalls in the current IDC training curriculum.

Table 11. Research question 1

How can the Navy provide frontline Subject Matter Experts (Independent Duty Corpsman—IDC) the means to efficiently and accurately track PPEs during COVID-19 type pandemics?

B. QUANTITATIVE RESULTS

Due to the limited data from the results, assumptions and partial data from Question 2 (Table 12) form the basis from which the required ROP variables are taken. Because of this limitation, the proposed onboard allowance, expenditure rate or PPE ROPs will not fully capture real-life scenarios. The application of the ROP formula will be the proposed solution in addressing the second research question in determining onboard allowance and can fulfill the purpose of the second phase of the this mixed-method study. The reasonable onboard allowance from the result of this phase is the safety stock supplemented with a forecasted ROP.

As stated in the methodology chapter, a stochastic ROP model is employed as the study considers the sporadic expenditure rates of N95 masks and the unpredictability of lead times which is dependent on a DDG's proximity to prepositioned stocks or ports, underway replenishment (UNREP) frequency, and availability of cross-level logistic support within attached or adjacent strike group elements. To appreciate the variability of lead time, the ROP will be applied using two scenarios with varying, assumed lead times. Both scenarios result in safety stocks and ROPs with the first executing orders from prepositioned sources and receiving supplies via UNREPs (Figure 18.). The second scenario involves requesting N95 masks via cross-level support (Figure 19.). Both scenarios have identical variables with the exception to their respective average lead times. The variables are based on a hypothetical period of 30 days with total expenditure rate of 6.6 per day. The prepositioned stock scenario assumes an average lead time of 23 days. This average time is from the point an order is placed with a prepositioned source to when the order is fulfilled or replenished in unscheduled UNREPs. The 1-day average lead time assumes that adjacent ships are within range with available stock on hand.

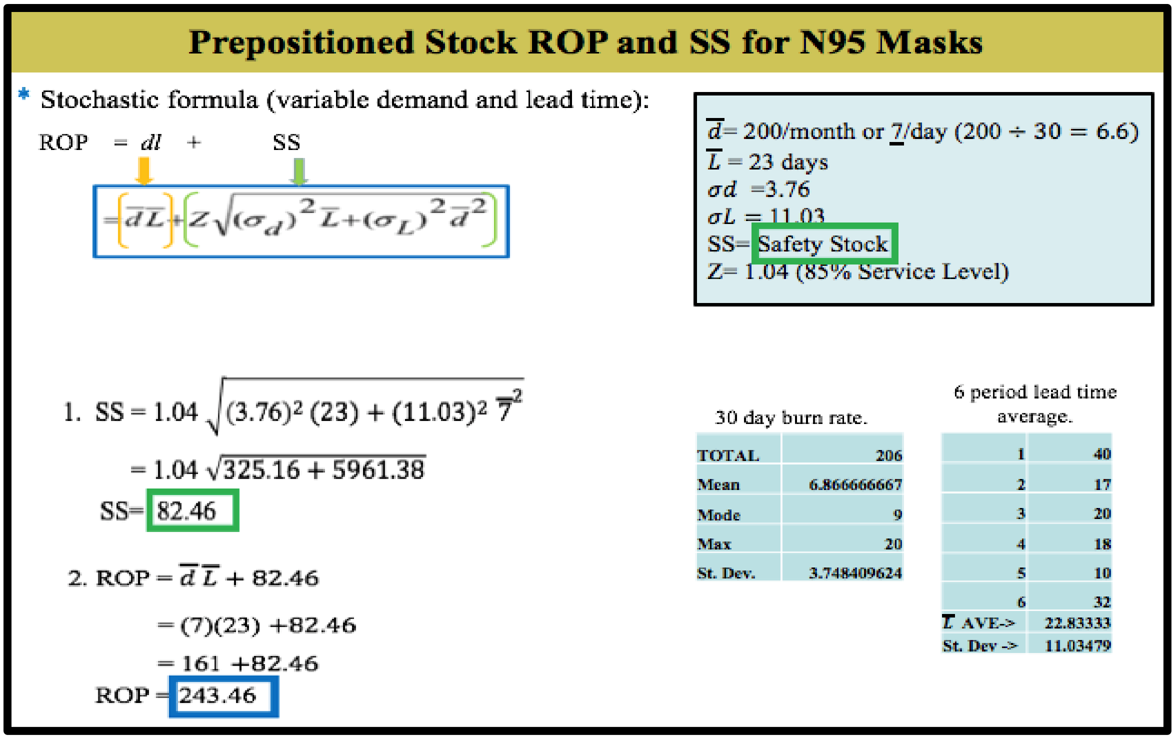

Figure 18. Reorder point and safety stock for N95 masks (prepositioned).

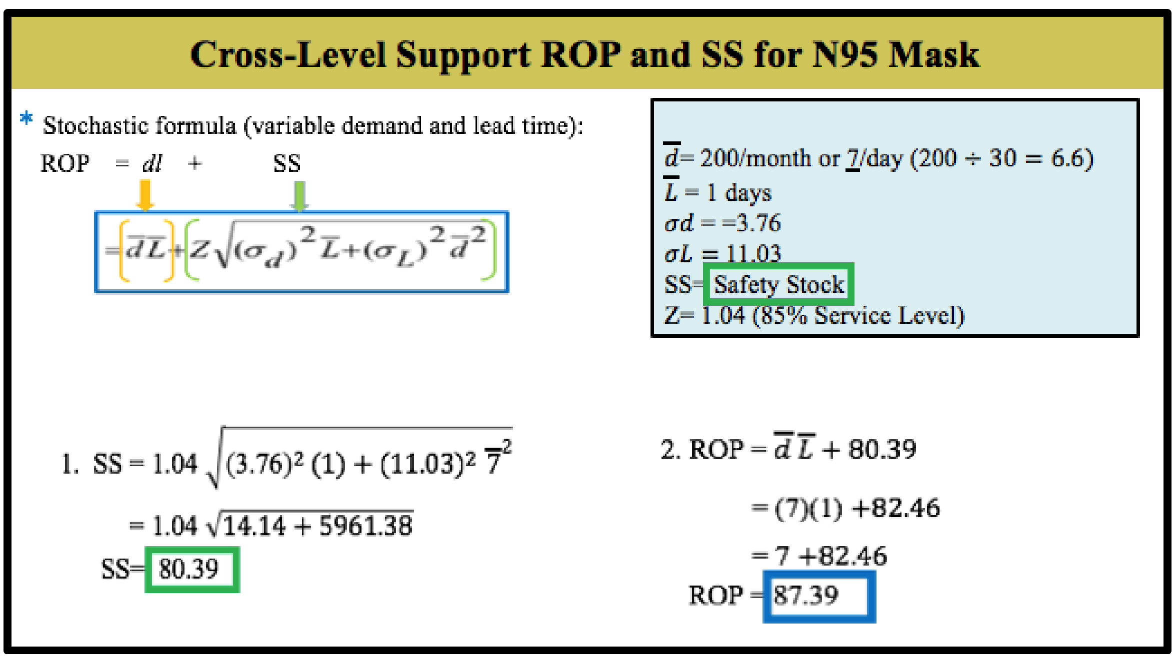

Figure 19. Reorder point and safety stock for N95 masks (cross-level).

1. Phase 2: Quantitative Summary

The assumptions in this phase allowed the demonstration of the ROP formula applied to shipboard supply chain management scenarios. Although the scope was limited to the N95 masks, this model can be employed for other PPE items or other mission essential supplies. The potential for automation with the use of Microsoft Excel on board DDGs and other ships would be a useful tool for IDCs in improving inventory management (Puonti, 2015).

The subsequent results in the prepositioned stock scenario produced an ROP of 243.46 units with a safety stock of 82.46 units. According to the stochastic ROP formula, a triggered replenishment action would be required once inventory levels reached 243.46 units remaining N95 masks. This result suggests a problematic on-hand AMAL requirement regarding N95 masks as the current assemblage requirement on the DDG is only 120 units (1 box/package). Outside pandemic-like situations, this requirement is sufficient to sustain a healthy crew of 340 sailors. On the contrary, a future COVID-19-type outbreak may pose operational strains on the crew, overall readiness, and mission related capabilities.

The cross-level support scenario had results of an ROP of 87.29 units and a safety stock of 80.39 units. This scenario provided numbers that are more reflective of the current DDG assemblage requirements, and hence more tenable when faced with emergent replenishment situations. The option for cross-level support would certainly be feasible assuming stock availability and range, but does not fall in line with standard operational procedures or processes. This replenishment option would not be ideal and this phase's cross-level scenario and its ROP formula would not be a viable tool as a sustained source in management of supplies.

This phase of the study addresses the study's second research question (Table 12.) and offers reasonable onboard allowances in two different scenarios. The safety stocks proposed resulting from the stochastic ROP formula may provide DDGs an inventory level to sustain on-hand stocks while preventing PPE stockouts in future pandemics.

Table 12. Research question 2

How can the Navy determine a reasonable onboard allowance for pandemic-related PPE given limits on shipboard storage and Authorized Medical Allowance List (AMAL) composition and an empirically-sound prediction for the usage rate of each category of PPE during a pandemic?

C. SUMMARY

Both phases of the study fulfilled their respective purposes and addressed the research questions. The qualitative phase coded interview responses and isolated themes to identify positive and sustainable supply chain management practices while identifying points of deficiencies in didactic and training environments. The potential for enhanced training opportunities is implied in these findings. The study followed a sequential research design prescribed by the literature by adhering to an Exploratory Sequential Mixed Method model (Creswell, 2014). In this design the researcher used the qualitative results of Core Question 2 to inform the second quantitative phase in application of instruments (variables) to aid in addressing the second research question (Table 13.). The second phase results addressed the minimum on-hand requirements of a PPE item, the N95 mask. Although the numbers (ROP and safety stock) presented do not reflect precise figures, the study provides a mechanism to employ toward the management of medical supplies onboard DDGs using a stochastic ROP formula.

Table 13. Research question 2

How can the Navy determine a reasonable onboard allowance for pandemic-related PPE given limits on shipboard storage and Authorized Medical Allowance List (AMAL) composition and an empirically-sound prediction for the usage rate of each category of PPE during a pandemic?

V. CONCLUSIONS AND FUTURE WORK

A. LIMITATIONS

The limitations of the study primarily stem from the limited data gathered and the deficient data available due the novel attributes of COVID-19 and the dynamic nature of the pandemic. Limitations from Core Question 2 was a prime source of the challenges as the responses yielded minimal consensus while the majority of respondents provided no response. The lack of answers in this example was not related to oversight or deficiencies in their abilities as IDCs but due to their limited time stationed on their respective ships or because they simply did not deploy during the pandemic. Mitigations for this limitation may be a larger sample size or more thorough selection of interview candidates by requiring pertinent experience during the COVID-19 era. Similar to states and organizations, the Navy and its fleet assets, including the Arleigh Burke class platform, had limited data as health crises ensued. A parallel study conducted at Naval Postgraduate School, noted data reporting processes as "burdensome," lacking "actionable decision data," inaccurate, and in need of automation (EJ Armstrong et al., 2021, p. 21).

Another aspect of potential limitations is the employment of the ROP as a fleet-based tool to manage supply chain on DDGs. ROP has prevailed throughout civilian industries where factors of lead time and demand lack the inherent variability that deployments and general ship movement pose. The stochastic ROP model presented in this study did not offer an automated solution to enhance the IDCs supply management capabilities. It was presented as a possible tool to determine ROP and safety stock. Without automation capabilities, an ROP-based supply management system may not be an ideal tool when primary functions revolve around patient care.

B. RECOMMENDATIONS

To establish viable supply chain management practices involving PPE in future pandemics accurate data standards must be established, use of ROP (Re-order Point) or similar models in supply management should be considered when underway, there must be sustainment of AMAL review boards, and supply chain training for IDCs must be enhanced.

1. Establish accurate PPE data inventory tracking standards.

Data tracking standards must start with meticulous inventory tracking at the ship level. Inaccurate inventory data communicated to higher echelons of the fleet has the potential to limiting decision-based updates to PPE inventories. More importantly, PPE, and all medical supply chain items, must have standardized tracking requirements when promulgated to ships and their IDCs.

2. Employment of an automated ROP model during shipboard medical supply management.

The use of the Stochastic ROP model to address variable demand and lead time would be an appropriate tool in supply management aboard DDGs and other vessels. Establishing a standard of use of an automated ROP model would further enhance this capability by providing IDCs simpler inventory management which would ultimately allow them to concentrate patient care. This is vital in cases of mass casualties, emergencies and future pandemics.

3. Sustain the AMAL Modernization Review.

The AMAL review process continues to be a valuable collaboration that takes into account current needs of the Navy regarding medical supply assemblage. Continued sustainment and support for this process will be key in maintaining agility in future pandemics. With the continued support of the TYCOM and the Fleet Forces Command Surgeon, to the logistical management of NAVMEDLOGCOM, and the valued input of medical SME, the 12–18 month cycled AMAL review will continue to make the appropriate changes when needed. And if capable, the major stakeholders should establish ad hoc reviews when abrupt changes are necessary, such as the case in the COVID-19 pandemic.

4. Enhancement of medical supply chain management training for the IDCs.

One major result from the study's interview process was the implied lack of supply chain training provided to the IDCs. This was evident in the didactic and fleet settings. To address this deficiency, program managers of the IDC curriculum or IDC specialty leaders that directly support the fleet must establish more effective and efficient training methods. Within the didactic setting, more formal training methods should be established in the subject of supply chain management. Training in systems such as DMLSS, TMIP, and SAMS should be sustained, but the curriculum could be further enhanced with supply chain management practices to include inventory tracking, ordering, and forecasting. The ROP model can be incorporated and can be applied in shipboard settings.

C. CONCLUSION

This thesis's research design addressed the demand and purpose for the current study by first presenting historical, comparative, and epidemiological pandemic data and the current impact of COVID-19 on population health and socioeconomic implications. The narrow scope focused on subject matter experts (IDCs) within the Arleigh Burke-class DDG platform and the optimized PPE (N95) supply chain management. A thorough literature review covered retrospective literature data and research design scholarship that supported the research methodology employed.

The thesis sought to address the problem– the potential of PPE shortages to the fleet, the adverse effects to overall readiness, and the preservation of the Navy's greatest assets, its sailors. In addressing this, two questions were posed as the study employed an Exploratory Sequential Mixed Method research design. The first phase of the research method was designed to answer the first research question– How can the Navy provide frontline Subject Matter Experts (Independent Duty Corpsman—IDC) the means to efficiently and accurately track PPEs during COVID-19 type pandemics? This first phase (qualitative) adopted a case study design leveraging interviews with IDCs. This process resulted in identifying positive attributes of base knowledge of understanding regarding available sources of policies related to supply chain. Of equal importance was the identification of an area of deficiency within the IDC's training curriculum. This implication elicited the recommendation of enhanced medical supply chain management training within the didactic level and possible fleet-based training solutions.

The second phase (quantitative) took elements from the first phase's interview results to inform the stochastic ROP formula with variables to address the second research question– How can the Navy determine a reasonable onboard allowance for pandemic-related PPE given limits on shipboard storage and Authorized Medical Allowance List (AMAL) composition and an empirically-sound prediction for the usage rate of each category of PPE during a pandemic? As some aspects of the qualitative phase yielded limited data, averages and assumptions were made to build and present the proposed stochastic ROP formula to determine a PPE (N95) safety stock (reasonable onboard allowance), and a reorder point. The prepositioned stock scenario resulted in a safety stock of 82.46 units and an ROP of 243.46 units. This result suggests a problematic on-hand AMAL requirement as the current DDG assemblage requirement is only 120 units. The second scenario, cross-level support, resulted in a safety stock of 80.39 units and an ROP of 87.29 units. Although this scenario resulted in a feasible outcome, this replenishment option is not ideal and should only be executed in contingent or emergent situations. This phase addressed the study's second research question and offered reasonable onboard allowances in two different scenarios. The safety stocks proposed resulting from the stochastic ROP formula may provide DDGs an inventory level to sustain on-hand stocks while preventing PPE stockouts in future pandemics.

The mixed-method Exploratory Sequential design effectively addressed the research questions while also producing results that helped provide recommendations germane to PPE supply chain management. The recommendations were centered on establishment of accurate PPE tracking standards, employment of an automated ROP model, sustainment of the AMAL periodic review process, and the enhancement of supply chain training solutions for IDCs. Future work may include expanding the scope to include other platforms in the fleet, incorporating optimal stockpiling or prepositioning of PPE stocks, research in technological forecasting innovations to inform notional AMALs, and studies that focus on efficient distribution of vaccines to the fleet and DOD personnel.

D. FUTURE STUDIES

Future research should be considered to build upon the results from the current study and enhance the Navy's resilience in potential pandemics. With a continued focus on medical supply chain, studies pertaining to other platforms such as LHD, LHA, CVN, and submarine classes should be considered. A vital accessory to platform-specific studies are studies that focus on PPE supply procurement. More specifically, studies that aim to determine optimal stockpiling and pre-positioning schemes should be considered to emphasize assured access and prompt replenishment to underway fleet assets. Studies such as these would be further complemented with research aimed at leveraging technological innovations involving forecasting methods to optimize PPE assemblage requirements that inform notional AMALs. Another relevant area of study to consider is the potential price gouging of PPEs as their use proliferated in the COVID-19 era. An area to consider would be how to establish dedicated stocks impervious national or international stock shortages and regulation of prices while securing procurement solutions economically beneficial to the DOD.

Lastly, as vaccine data is gathered, there may be high demands for studies identifying obstacles and leveraging solutions for efficient means of distribution across the fleet. Such studies should take into consideration the effects of vaccine stock and efficacy as COVID-19 variants arise. Contingency supply chain planning should still be emphasized across the fleet to ensure readiness across the fleet - and perhaps even extending to all branches of the military. Current processes involving NAVMEDLOGCOM and Content Managers (Commander-Fleet Forces, Command Surgeon, Type Commander Surgeon) offer annual reviews of AMAL composition across the fleet where SME participate in a November time frame conference to discuss changes (Allowance Change Requests) (ACR). Discussions are based on thoughtful insight from SME experience and scholarship regarding medical care and how to leverage the supply chain. Theoretically grounded automated innovations might aid in a more standardized method of forecasting individual needs of commands/platforms.

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APPENDIX A. HUMAN SUBJECT DETERMINATION REQUEST

NPS Institutional Review Board

Human Subject Research Determination Request

Purpose:
To request the IRB review proposed activity and determine if it involves human subject research.

Form Instructions:
To receive an official determination, submit the following to IRB@nps.edu.

1. Determination request form signed by the Principal Investigator (PI). *Note: The PI for student research is the advisor.*
2. A copy of the research proposal or statement of work.
3. Attach any data collection tools (i.e. interview or survey questions, etc).
4. Submit signed determination form and corresponding documents to IRB@nps.edu. An IRB administrator will contact you if additional information is needed.

For questions regarding this form or process send an e-mail to IRB@nps.edu. Form Updated 1-22-19

A. Research Basics

Title of the Activity:	Thesis - Medical Supply Chain in the COVID-19 Pandemic Age: An inquiry on current policies towards notional modifications to shipboard Authorized Medical Allowance List (AMAL)
Department:	Information Science Dept
Principal Investigator:	Douglas J. MacKinnon, Ph.D.
Co-Investigators:	
Student Researchers:	LT Michael Encoy, MSC, USN

B. Data Collection

1. Will the activity include the use of secondary information or biospecimens? Secondary information or biospecimens are forms of data that already exist or will be collected for another primary purpose such as fitness reports, personnel records, training records, after action reports, social media data, information from data repositories, existing survey data, biospecimens from salivary, tissue, or blood repositories, etc.

☐ No

☒ Yes, state the following below:

- Describe the information or biospecimens (is it training records, fitness reports, information on all active duty by speciality, biospecimens from a previous clinical trial, etc).
- State the approximate number of records you will access.
- List the information variables or types of biospecimens to which you will have access. Make sure to include any PII or demographics contained in the information or biospecimen samples.

Policies, instructions, after action reports, lessons learned reports, supply data bases

2. Will the activity involve interaction with people?

☐ No

☒ Yes, describe what tasks subjects will be asked to perform (take a survey, be interviewed, participate in a simulation, play a game etc.) and what information subjects will be asked to provide.

Interviewees will be asked about current processes and specific policies in which they adhere to in the management of shipboard AMALs. The researchers will only be concerned with non-subjective responses to inform the study.

3. If a proposal or statement of work is not available, describe the purpose of the data collection and how the data will be used.

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APPENDIX B. HSR DETERMINATION CHECKLIST

NPS IRB
HSR Determination Checklist
last updated: 1-22-19

Instructions: This form is to be completed by the IRB Chair or Vice-Chair when providing an official IRB determination on whether a proposed activity meets the federal definition of research with human subjects according to 32 CFR 219. After completing the form provide it to the IRB Administrator. The IRB Administrator will notify the investigators and file electronically.

Title of the Activity: **Medical Supply Chain in the COVID-19 Pandemic Age: An inquiry on current policies towards notional modifications to shipboard Authorized Medical Allowance List (AMAL)**

Department: **GSOIS**

Principal Investigator: **Douglas J. MacKinnon PhD**

Co-Investigators:

Student Researchers: **LT Michael Encoy, MSC, USN**

Determination Criteria

		Yes	No
1.	**Is the activity research?** *For the activity to be research both (a) and (b) must be answered in the affirmative.*		
(a)	Is the activity a systematic investigation?	☒	☐
	Student thesis with proposal		
(b)	Is the activity designed to develop or contribute to generalizable knowledge?	☒	☐
	Seeks to suggest modifications to Navy-wide authorized medical allowances and prepositioned stocks		

If you have checked "no" to 1(a) or 1(b) skip to "IRB Determination" the activity does not meet the definition of human subject research.

		Yes	No
2.	***Does the activity involve the use of human subjects?*** *For the activity to involve human subjects (a) and [(b) or (c)] must be answered in the affirmative.*		
(a)	Is the activity designed to collect information about a living individual or use secondary information or biospecimens data about a living individual?	☐	☒
	Activity is designed to collect information "about what", specifically, about ship and fleet inventory levels and to suggest modifications to authorized medical shipboard allowances and prepositioned stock		
(b)	Does the activity involve interaction with a person or persons?	☒	☐
	Interviews asking "about what" questions pertaining to inventory level depletion of certain medical inventories, policies governing supply maintenance of medical items, and types of training for medical supplier managers; only one question asks about a person, specifically what office is involved in a certain aspect of the study		
(c)	Does the activity involve the use of secondary information or biospecimens that are both private and personally identifiable?	☐	☒
	Secondary information includes policies, instructions, AARs, lessons learned reports, and supply data bases. The researchers state the providing organizations will remove all PII from the AARs and lessons learned reports before submitting to the researchers.		

IRB Determination

	Yes	No
The attached activity involves human subject research and require IRB and NPS President approval.	☐	☒

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APPENDIX C. QUALITATIVE INTERVIEW QUESTIONNAIRE (EXCEL FORMAT)

N-167 Thesis Questionnaire:

****THANK YOU FOR TAKING PART IN THE STUDY, AS PREVIOUSLY MENTIONED YOUR PARTICIPATION AND/OR PERSONAL OPINIONS WILL NOT BE SHARED OUTSIDE OF THE INTERVIEW VENUE BESIDES CLEARLY DEFINED AND GENERIC QUESTIONS PERTAINING TO DEMOGRAPHICS, MILITARY EXPERIENCE, AND OBJECTIVE PROCESS & POLICIES PROMULGATED WITHIN YOUR OCCUPATION/SPECIALTY****

DATE	
NAME	
RANK	
MEDIUM	
SECTION 1 **GENERAL BACKGROUND QUESTIONS**	
1	How old are you?
2	How long have you been in the Navy?
3	How long have you been an IDC?
4	How many ships have you been on as an IDC?
5	List your duty stations as an IDC?
SECTION 2 **POLICY, PROCEDURE & PROCESSES QUESTIONS** **(What we are looking for here is commonality or divergence of practices or sources of policies from participants that may hinder standardization of processes across the fleet)**	
1	Who (person/organizational entity/POC) provides you (as an IDC) supply chain inventory, ordering, tracking, storage) support or guidance underway and pier side?
2	What was the 'burn rate' of PPE during deployments (during and pre COVID-19 Pandemic)?
3	What was the 'burn rate' of testing kits during COVID-19 Pandemic?
4	What policies/instructions provide guidance to maintain supplies.
5	What policies/instructions provide guidance to maintain supplies (tracking, frequency of inventory and management) during the COVID-19 Pandemic.
6	What type of didactic or follow-on training was provided as the primary manager (IDC school or other)?

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